VOLUME 18, NO. 1
JANUARY 1986

THE SHOCK AND VIBRATION DIGEST

A PUBLICATION OF
THE SHOCK AND VIBRATION
INFORMATION CENTER
NAVAL RESEARCH LABORATORY
WASHINGTON, D.C.

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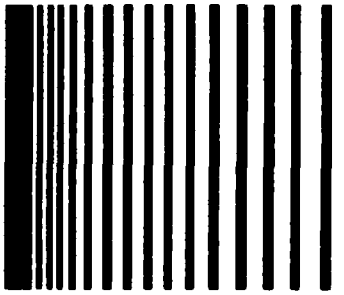

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Volume 18, No. 1
January 1986

A publication of

THE SHOCK AND VIBRATION INFORMATION CENTER

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SVIC NOTES

We Get Questions

One of the features of SVIC's service package is the availability of a staff member to answer technical questions pertaining to shock and vibration. Most of the requests for information are received by phone, but sometimes they arrive by letter, or by discussions at meetings, or during technical visits. But, whichever way we receive the request, we discuss the problem with the requester to be sure we understand it, and to decide the best way to reply.

I examined the past year's requests for technical information, and I found the types of questions could be divided into the following groups, which are listed in the order of the frequency of their occurrence:

Environmental data

Testing facilities and techniques

Shock and vibration control

Analysis and design techniques

Most of the technical information requests are unique since we rarely have to answer the same request for several years.

Technical questions in some categories are harder to answer than in others. Questions related to environmental data, regardless of the vehicle, are good examples. These questions are often the most difficult to answer because the information may not be readily available. Environmental data on a specific vehicle may be available, but it may not be available at all locations; according to "Murphy's Law," it will not be available at the location(s) where it is needed. Sometimes we learn no measurements were ever made, or if they were made, they were below the instrumentation noise floor. Some feel both of these facts are useful information.

Typical questions in the other groups concerned the availability of facilities for testing large payloads or simulating extreme environments, the properties of damping materials, sine-random equivalence, and the availability of computer programs. Most of the questions in these categories are easily answered because a large body of information is available.

We have many information resources at our disposal for answering requests; these include papers in technical journals, technical reports, books, literature reviews, and other information analysis centers. The nature of the request dictates the source(s) of information and the approach used to reply; but our first approach is to try to find published information. Sometimes we might refer the requester to another information analysis center because the scope of the request is broad enough to be of interest to more than one center.

We receive many challenging and interesting requests for information each year, and I think both we and the requesters learn something from them. We learn more about the shock and vibration technology during our search and analysis of the literature, and these requests for information often provide insight into the on-going work in this technology.

EDITORS RATTLE SPACE

LET'S ELIMINATE THE LEAST PUBLISHABLE UNIT

The least publishable unit (LPU) is a technical article which contains the minimum amount of technology necessary to obtain refereed or nonrefereed publication. Because of the use of the LPU, many proceedings and journals now contain numerous short disjointed articles which are difficult to use. The LPU and republication are in my opinion responsible for the current literature explosion. In fact the LPU itself is responsible for a certain amount of republication. Due to these facts the literature explosion has not brought us extensive valuable new technology which can be applied to the solution of problems. While new techniques like experimental modal analysis and computational finite element analysis have been developed in recent years, fundamental research on modeling still lags because it is time consuming and difficult.

The LPU tends to provide literature which is difficult to retrieve because sections of a technique and/or its applications may be published at different times in different journals. When Cambell published his extensive work (over 100 pages) on blading in 1924 it was in one article in the ASME transactions. Indeed it was a minimonograph in length. By today's standards this famous article would have been severed into about 10 LPUs. This practice makes the difficult job of technology retrieval almost impossible.

Why do we have the practice of LPU publication? It appears that the authors and publishers work together and the referees (if there are any) look the other way. The authors want to publish the maximum number of papers because it increases their prestige. The publishers want to restrict the number of pages printed because of the editorial and printing costs. Therefore the two most important parties in the publishing process unwittingly work together to form a disjointed literature.

I believe there is a very simple solution to this problem. Let the publisher restrict the total number of journal pages rather than the total number of pages per article. In addition, it would help to have referees look at articles from the point of view of direct, uncluttered presentation so that excessive verbage is not present. Let the technical community and its superiors judge the author on quality of publication rather than quantity. I see some signs in that direction in many universities in their evaluation of tenure candidates. I believe it is possible to eliminate the LPU, reduce publication costs (by avoiding duplication), and provide a more retrievable literature.

R.L.E.

BEHAVIOR OF ELASTOMERIC MATERIALS UNDER DYNAMIC LOADS — IV

C.A. Caseiro*

Abstract. This is a review of literature published since 1982 on the behavior of rubber materials under sinusoidal forces. The most significant advances concern the correlation of dynamic properties and molecular structure.

This is the fourth review of the state of the art of rubber that is subjected to sinusoidal stresses. The three previous reviews were presented in 1976 (1), 1979 (2), and 1982 (3). Publications since 1982 are cited.

GENERAL

Work on elastomers in the past three years has emphasized the correlation between molecular structure and dynamic properties. Included are analyses of copolymers, interpenetrating networks (IPN), and altered monomers. Improved theoretical analyses of elastomers under dynamic loads involve constitutive equations and the fast fourier transform technique. These analyses are used to provide the best elastomer for dampers and acoustical coatings. Dynamic tests and properties are diverse. Resonance and non-resonance techniques are used to solve for these properties. Test configurations provide test data for specific frequency and temperature ranges. Research continues in dynamic testing and correlation of molecular structure and dynamic properties.

Some of the most interesting work in the past three years has involved the relationship between the molecular structure and dynamic properties of viscoelastic materials. An investigation of a block copolymer of styrene and isoprene (4) was concerned with dynamic properties in relation to micro-structure. In heterophase the copolymer obeyed the WLF function for determining the shift factor. The data presented, however, are limited. The effects of acrylonitrile level in a butadiene-acrylonitrile copolymer were examined using a Rheometrics spectrometer (5). Blending polyurethane and epoxy broadened the material damping region; the sharp peak of the urethane was lowered, and the sharp peak of the epoxy was raised. Dynamic testing of a polyurethane polymethylmethacrylate IPN indicated two glass transition temperatures corresponding to the components in the network (7). These investigations indicate the type of tailoring available when elastomers with disparate glass transitions are combined.

The use of dynamic testing to evaluate the molecular structure of polyurethanes has been described (6, 8-10). Wong and Williams (6) describe results due to changing the bulk of the backbone and the comonomer ratio. In other work (8) the introduction of benzene rings to diol-cured polyurethanes shifted the glass transition higher than did the introduction of aliphatic diisocyanates. Thermal treatment of polybutadiene polyurethanes reduced the loss factor and storage modulus by increasing the length of the hard segment block (9). A differential scanning calorimeter and a rheovibron were used to classify molecular relocation processes and the qualitiy of microphase separation in a UV curable polyurethane. (10).

Several papers have been written on the analysis of viscoelastic properties of elastomers. Rogers (11) used Bode diagrams to synthesize analytic expressions to represent dynamic properties. He describes the increased efficiency of earlier constitutive equations. This thorough paper provides a good explanation of the function of viscoelastic dampers. Soni (12) used a finite element computer program to predict the response of damped structures to steady-state inputs. This analysis is useful in determining the type of damping required to reduce vibration effects. An iterative analysis involving lumped parameters has been described for anti-vibration mounts (13). Dynamic testing of neoprene as well as natural, butyl, and nitrile rubber in a limited frequency range was used to verify the analysis.

Beatty and Chow (14) described a theoretical analysis of a loaded rubber string; they used elementary functions and the Heuman lambda function. An interesting analysis of several viscoelastic materials under acoustical loadings has been published by the Naval Surface Weap-

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ons Center (15). Physical models for several elastomers were developed to allow better matching of theoretical and empirical data when several decades of frequency are involved. Gaunaurd (16) predicted the dynamic behavior of elastomers containing randomly distributed air voids.

TESTING

The torsional pendulum continues to be one of the most widely accepted methods for testing the dynamic properties of elastomers. Advances in peripheral instrumentation allow data to be taken over larger temperature and frequency ranges. A modified torsional pendulum has been used to obtain the loss factor and dynamic elastic moduli of a triblock styrene-butadiene-styrene (17). The data were compared with a modified Nielsen modal analysis. Shifting data from one temperature/frequency range is difficult with copolymers; an improved torsional pendulum technique described in the article extends the testing range. Another forced torsional vibration technique has been described (18). The shear loss and storage moduli of a void-filled polyurethane are presented. Shear properties are typically presented with this technique.

Digital spectral analysis has been described (19, 20). In one case (19) data were obtained for a wide frequency range by exciting the test specimen with random white noise; complex moduli were calculated from the measurements. The system is computer controlled; data are reduced with the same computer. Madigosky (20) used a clamped-free specimen subjected to a random noise over the frequency range of 25 Hz to 20 KHz and a temperature range of -13.4°C to +81°C. Data are obtained at the resonance peaks. The author states that this method is an improvement of one previously used and provides greater accuracy and easier operation. The digital spectral analysis test method provides dynamic data over a wide frequency range with one test run, but it is a resonance technique. The specimen size must be changed to obtain data at specific frequencies.

The Fitzgerald apparatus has been used for many years to obtain responses to low-amplitude dynamic stresses. Elastic and loss shear moduli and compliances using this test method have been presented (21, 22). The apparatus is described in detail (21). Another low-amplitude strain technique used in the past has been the Rheovibron, which has only four test frequencies and is used in the tensile mode; it has been described (9).

Several papers have been devoted to testing methods for viscoelastic materials. Techniques for obtaining dynamic properties for elastomeric damper application were described (23), as were the mechanical properties of polymers, friction damping, design of damped structures, damping applications, and experimental methods. Unique methods for obtaining complex moduli and loss factors, including dynamic testing in a vacuum were also described (23).

DYNAMIC DATA

Dynamic data for various elastomers are wide ranging because of the many test methods used. Most data are based on low strain amplitude measurements under low or no static loads. Sullivan (24), however, presented dynamic properties of several natural rubbers subjected to large static deformations. He gave storage and loss moduli for a carbon black filled and an unfilled natural rubber subjected to static loads. These results were inconsistent when compared with the modified finite linear viscoelasticity theory. The author states that the frequency dependence of the elastomers was independent of static and dynamic strain effects.

Tests on the Fitzgerald apparatus to determine the dynamic properties of several elastomers have been described. They involve the analysis of temperature/frequency superposition. Data were obtained for some gum rubber vulcanizates and some carbon black loaded vulcanizates (22). The data indicate that the superposition technique is usually unsuccessful in composite systems in which each of two phases contributes to the viscoelastic properties. The complex shear compliance and modulus have been given for a butyl rubber stock and a polyisobutylene in the ranges of 0°C to 100°C and 25 Hz to 2500 Hz (25). Results indicated that carbon black loading left frequency dependence unchanged, lowered compliance, and increased the modulus.

Work at the Naval Research Laboratory on several polyurethanes and a butyl rubber has been presented (26). A resonance technique was used to solve for the dynamic Young's modulus and loss tangent of commercially available test specimens in the frequency range 10 Hz to 10 KHz. Madigosky (27) presented the dynamic shear modulus and loss factor for a neoprene rubber. This work is interesting because it describes an attempt to measure long-term, low-temperature stress effects on the rubber studied. A digital spectral analysis technique (20) was used to study the effects of crystallization of the polymer (27). For the temperature range -20°C

to +25°C no crystallization effects were imposed on the neoprene (27). Research should be continued on polymer crystallization and its effects on dynamic properties. A study of temperature and pressure on a urethane elastomer has been reported (28). Ultrasonic velocity measurements were used to do a dynamic evaluation.

A Rheometrics mechanical spectrometer has been used in two studies (29, 30). In one study (29) the spectrometer was used from 30°C to 70°C in a frequency sweeping mode on an oil-extended ethylene-propylene copolymer; storage and loss moduli were obtained. Superposition principles were used to extend the data to determine the effect of the oil addition. The study does not mention the possibility of superposition variation due to copolymer interaction. Dynamic properties were presented on Epcar and Hycar polymers in the second study (30). The polymers were tested under large static loads. Relaxation of the elastomers was measured at instantaneous deformation, constant rate of deformation, and after the dynamic load was applied.

APPLICATION

The applications of elastomer dynamics technology have been as wide ranging as the data presented. Damping of vibration comprises a large part of the technology. Several applications of elastomers as dampers have been described (23), particularly in the commercial and military aircraft industries. Stahle and Staley (31) described the application of an elastomer to spacecraft structures in order to provide damping. Dynamic shear modulus and loss factor for a General Electric elastomer were used to damp spacecraft vibration. The properties were incorporated in finite element and modal strain energy methods. An interesting study of dynamic properties of several pressure sensitive adhesives has been described (32).

The application of the dynamic properties of elastomers has been useful in the automobile tire industry. Two papers on the use of polymer viscoelasticity in the evaluation of tire service life are of interest (33, 34). The first paper contains Rheometrics thermomechanical spectrometer data used to evaluate nylon-cord biasply passenger car tires. The use of nonlinear theory to characterize the polymer for strains larger than one percent was examined. Testing was done from 0.5 to 15 percent strains. The author states that the characterization was marginally successful. In the second paper (34) a test method was used to simulate deformation in the steel reinforcement of the sidewall of a radial tire. A new approach to measuring dynamic losses in rubber-steel cord composites was described. The decay of the free oscillation amplitude was used to measure energy losses.

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LITERATURE REVIEW: survey and analysis of the Shock and Vibration literature

The monthly Literature Review, a subjective critique and summary of the literature, consists of two to four reviews each month, 3,000 to 4,000 words in length. The purpose of this section is to present a "digest" of literature over a period of three years. Planned by the Technical Editor, this section provides the **DIGEST** reader with up-to-date insights into current technology in more than 150 topic areas. Review articles include technical information from articles, reports, and unpublished proceedings. Each article also contains a minor tutorial of the technical area under discussion, a survey and evaluation of the new literature, and recommendations. Review articles are written by experts in the shock and vibration field.

ROTOR INSTABILITY IN CENTRIFUGAL PUMPS

D. France*

Abstract. The literature describing rotor instability phenomena in centrifugal pumps is reviewed. Discussion is confined to subsynchronous instabilities classified according to origin and in terms of the fractional frequency ratio of occurrence. When possible, the underlying mechanisms of the instabilities are described.

Instances of potentially damaging vibrations have increased as the power and speed of modern centrifugal pumps have increased. In the field of rotating machinery dynamics it is generally accepted that severe vibrations can result from high level synchronous unbalance excitation and the proximity of operating speed to a critical speed of the rotor.

Such problems are not uncommon with centrifugal pump rotors and are generally well understood. Good rotor-dynamic design practices can help avoid most problems; but one class is more difficult to understand and predict because the vibrations are not synchronous with machine speed. These so-called nonsynchronous problems are potentially hazardous because of the self-exciting nature of the response. In this sense self-exciting follows the classical definition in which energy is transferred from a power source to a vibrating object as a result of motion of the vibrating object. This paper reviews the current state of knowledge of mechanisms and probable sources of destabilizing excitations that give rise to nonsynchronous rotor vibrations in centrifugal pumps.

LITERATURE REVIEW

One of the earliest works on synchronous shaft whirling can be attributed to Rankine [1]; nonsynchronous whirling due to journal bearing instability is attributed to Newkirk [2]. But it was not until the 1950s that fine fluid clearance seals in centrifugal pumps were mentioned in the context of rotor-dynamic excitations and response rather than in the context of leakage characteristics. Lomakin [3] recognized the importance of hydrostatic stiffness and its effect on critical speed. But it was Marcinkowsky and Karincev [4] who first reported evidence of damping effects attributable to fine clearance seals; they cited instances of nonsynchronous whirling at the natural frequency of the rotor when the pump was operating at high speed. Some years later Black [5] identified hydrodynamic effects in these fine clearances and extended Lomakin's theory to account for such effects. In so doing he quantified damping effects and predicted the possibility of nonsynchronous whirling at speeds in excess of twice the first critical speed of the pump rotor.

It has since been confirmed experimentally [6] that rotor instability due to fine clearance seals occurs at ratios of 0.5 times rotor speed or less -- less in the case of a resonant whip excitation when the operating speed exceeds twice the first critical speed of the rotor.

The first example of nonsynchronous whirling at ratios greater than 0.5 times rotor speed --around 0.6 - 0.8 -- was reported by Brown [7]. That the ratio appeared reasonably constant over a wide range was explained in terms of a hydrodynamic cross coupling force; the force acted in a forward driving sense (destabilizing) as a result of interaction between impellers and diffusers of the pump. The existence of such potentially destabilizing forces can be seen in the results of radial impeller force measurements presented by Hergt and Krieger [8].

One experimental investigation [21] contained examples of nonsynchronous whirling of a centrifugal impeller in a casing. It was concluded that the fluid has a profound influence on the dynamics of a radial vaned impeller and that destabilizing effects were present.

It was Black [9] who first attempted to rationalize the findings of Hergt and Krieger [8]. The semi-empirical theoretical analysis he developed was based on perturbations of impeller outlet velocity triangles. He used this analysis to account for the apparent dependency of cross coupling forces on relative slope in the clearance between eccentric impeller and diffuser. He

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also showed the possibility of nonsynchronous whirling at 0.6 -0.8 times rotor speed due to impeller/diffuser interactions. Similarity of this instability mechanism to that described by Alford [10] for centrifugal compressors and later analyzed by Ehrich [11] will be of general interest to readers requiring further explanation of the phenomenon.

The work of Hergt and Krieger [8] also identified the dependency of unsteady components of impeller radial force on eccentricity of the impeller within the volute or diffuser and the flow rate in the impeller. A good example of pump rotor response attributed to such unsteady components of force has been published [12]; sub-synchronous ratios of about 0.1 times rotor speed were observed at low-flow operating conditions in the pump.

Until a 1978 report was published [13] little serious attention had been paid to instability problems of centrifugal pumps. This report focused on instabilities that had been observed in feed pumps in electrical utilities in the United States. The frequencies of sub-synchronous hydraulically-induced dynamic forces were divided into three areas.

> 0.1-0.35 times rotor speed: claimed to be present in both diffuser and volute type pumps between 25% and 50% of best efficiency flow due to radial hydraulic force-induced whirl
>
> 0.45-0.55 times rotor speed: due to unstable journal bearings, fine clearance seals, or internal rubs
>
> 0.6.-0.8 times rotor speed: due to hydraulically-induced whirl that can be strong for both volute and diffuser pumps; can be reduced in some cases with tilting pad journal bearings or fine clearance seals; usually dominant between 25% and 50% of best efficiency flow

This work was a valuable compilation of the different forms of instability in centrifugal pumps but contributed little information about the mechanisms involved or the techniques available to avoid problems. Nevertheless, its publication stimulated the pump industry, researchers, and academic institutions to investigate destabilizing mechanisms in pumps due to hydrodynamic sources.

Recent experimental work describes lateral hydrodynamic forces of a centrifugal pump impeller performing circular whirl motions within several volute geometries [14]. This work defines for the first time the regions of destabilizing hydrodynamic forces with respect to whirl. These data will be of immense benefit to researchers involved in validating theoretical models being developed to predict the magnitude of hydrodynamic forces for any impeller diffuser or volute combination.

SOME INSTABILITY MECHANISMS

This section is devoted to an explanation of potential destabilizing excitations in centrifugal pumps.

Rotating Stall in Diffusers. Rotor instabilities due to stall generally occur at flow rates well below the best efficiency flow of the pump. The excitation frequencies are usually low with respect to synchronous speed, usually less than 0.25 [7, 12, 13]. As the flow rate decreases, the inlet flow to the diffuser readjusts; the resulting local recirculation can quickly progress to stalling in one or more diffuser passages. Interaction of the recirculated flow with the impeller propagates the stall forward; the stall pattern in the diffuser can rotate regularly from 2% to 25% of synchronous speed. The stall can be less regular for any of several reasons: interaction with recirculation zones in the eye of the impeller, multiple stall cells in the diffuser, or phase cancellation of stall cells in the diffusers of multistage pumps.

It is to be expected that dependency on impeller eccentricity [8] leads to feedback through rotor motions. A good example of rotating stall in a multistage boiler feed pump is given in Figure 1, [12].

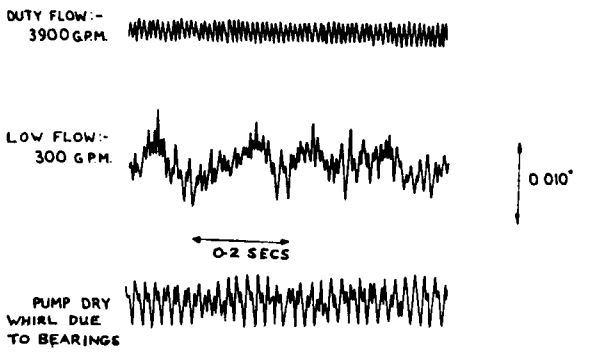

Figure 1. Vibration Measured at the Pump Discharge End Gland

Impeller Stall. It has been said that the possibility of flow-induced rotor instabilities due to flow stall at an impeller inlet is equally severe for diffuser or volute stages [13]. The onset of recirculating flow in an impeller inlet can spread across an impeller passage and stall it. The increased backflow from a stalled passage then promotes stall in the following one, thereby establishing a rotating pattern. Stalls of this type rotate fairly slowly through the impeller; the rotor is thus subject to a fairly fast subsynchronous rotating force of frequency $N + \Delta N$, where N is synchronous speed, depending on the direction of stall propagation in the impeller. Ratios of 0.6.-0.9 times rotor speed have been reported. Single stall cells appear worse than multiple stall cells. The latter usually oppose each other in the impeller inlet reducing the net force on the impeller.

An example of impeller stall-induced instability from the author has not previously been published. Figure 2 shows shaft vibration at the bearing from a variable speed test on a multistage diffuser pump. Dynamic pressure measurements were made across the first stage impeller inlet at two positions 180° apart. Sum and difference measurements of the two pressures showed that the nonsynchronous frequency pressures were out of phase across the inlet; a net resultant fluctuating force on the impeller was thus confirmed. The author has determined that a stall in the inlet can be reinforced by feedback of rotor vibration, radial and axial rotor eccentricity within the diffuser or volute, or some interaction with leakage through fine clearances to the impeller. This is an important area for future research in hydrodynamic instability in pumps.

Impeller and Diffuser Interactions. It has been concluded [8] that outward radial forces -- due to impeller eccentricity -- as well as cross coupling components of radial force are present to some degree in all impeller and radial diffuser combinations. The outward radial force has the appearance of a negative stiffness to the rotor. The cross coupling forces are potentially destabilizing because they lead impeller eccentricity in the direction of rotation. Experimental work [14] has largely confirmed this early work.

Black [9] showed that negative radial stiffness counteracts the hydrostatic stiffness of fine clearance seals thus tending to reduce the critical speed of a rotor. The cross coupling forces can destabilize a rotor; sub-synchronous whirling typically occurs in the range of 0.6-0.8 times running speed. This instability can be overcome

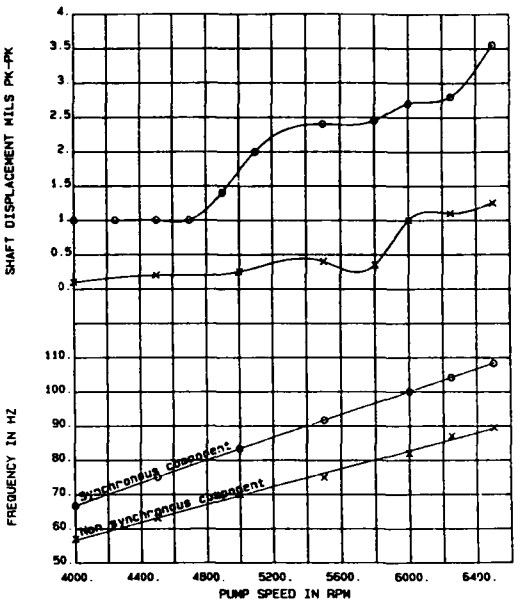

Figure 2. Frequency and Amplitude of Shaft Displacement from Variable Speed Test

by stiffening the rotor, either by stiffening the shaft or improving fine clearance design. Examples of this type of whirling are not often reported but have been cited [7, 13].

Cavitation Related Instabilities. The presence of cavities in the suction of an impeller can cause serious surging oscillations and subsequent rotor oscillations and vibrations [15]. An experimental investigation into low-flow frequency hydrodynamic phenomena responsible for rotor and pipe system instabilities has been reported [16]. The pump deviated from an essentially passive response without cavitation to an increasingly active response as the cavitation number was reduced. A relationship between cavitation and pump instability would seem to be proved by these findings.

Much of the work to date indicates that inducer dynamics, rather than conventional impeller designs, is responsible for POGO instabilities in rocket fuel pumps. However, evidence presented by Black [17] attributed surging oscillations and vibrations in boiler feed pumps to vortex-induced cavitation in the impeller inlet under low-flow operating conditions. Cavitation related vibration phenomena must be regarded as a major area for future research into hydrodynamic sources of instability in centrifugal pumps.

Fine Clearance Seals. If properly designed, the bearings of fine clearance seals are usually

stabilizing and control rotor vibration response [18]. But, because leakage is a problem, many seals are designed with deep grooves or stepped labyrinths to increase flow resistance and hence reduce leakage. Bearings can be drastically changed by deep grooves, however [19]. If the cross coupling terms dominate direct terms in the stiffness coefficient matrix, instability can occur at speeds at which the rotor would typically be stable with shallow grooved or plain seal designs. Instability due to seal cross coupling occurs at speeds at or beyond twice the first critical speed of a rotor; the instability is thus a resonant whirl or whip phenomenon identical to journal bearing-induced instability.

In stepped labyrinth seals the situation is more complex; instances of rotor instability have been reported. In one case [4] the mechanism of instability was not advanced. It was claimed, however, that in a three-pass stepped labyrinth, (Figure 3) the gap b_2 is crucial to stability. If $b_2 > b_1$ and b_3, the labyrinth is likely to be stabilizing; If $b_2 < b_1$ and b_3, the labyrinth is likely to be destabilizing.

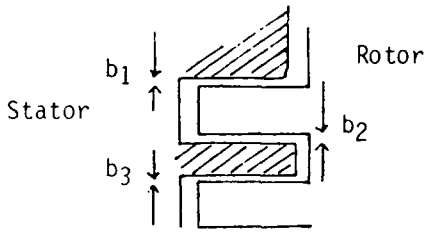

Figure 3. Three Pass Labyrinth

The bearings of fine internal clearance seals are probably the most important feature that governs and shapes rotor vibration response of a centrifugal pump. The point at which the seals act as stabilizing elements or as destabilizing elements is compromised by such considerations as leakage control, material compatability, and wear resistance. Future research will require good experimental data to correlate available theories. Experimental facilities required to further the state of knowledge have been described [20].

Rotor-dynamic Design Considerations. Rotor-dynamic considerations follow basic shaft sizing, bearing center distances, and details of impeller stage layout in pump design. Shaft sizing usually assures reliable pump operation at low flows and is bound to such input design parameters as speed, torque input, pressure rise, hydraulic efficiency, and cavitation performance.

Checks usually involve determining responses likely to force synchronous unbalance. This check helps to confirm the choice of bearing and drive coupling as well as the acceptability of shaft dimensions and overhung lengths of shaft beyond the bearings. Design of fine clearance seals shapes rotor response and assures that no instabilities will arise from seals or bearings. Clearances of worn components should be noted to assure satisfactory response and stability.

If it is known that a pump will operate under low flow conditions, a reassessment of shaft diameter will reduce the dependency of overall stiffness on fine clearance seals.

With low-flow operation some rotor instability of a pump is probable. The pump may be susceptible to hydrodynamic destabilizing forces; with the current state of knowledge only notional account of the magnitudes of the disturbances can be used in any rotor-dynamic analysis. Nevertheless, it is a sensible precaution to evaluate stability margins with reference to changes in bearing stiffness and damping, shaft diameter changes, and fine clearance design.

Data now being generated are being made available to researchers and engineers. It is expected that they will be used to evaluate and improve theoretical predictive methods that will be of value in rotor-dynamic design and evaluation of centrifugal pumps.

CONCLUDING REMARKS

An urgent need is to expand and develop experimental facilities to quantify hydrodynamic destabilizing forces in a centrifugal pump. Areas of interest are impeller/diffuser or volute interactions, stall in impellers and diffusers, cavitation and NPSH related dependencies, and fine clearance seal geometry effects

It is likely that development of accurate mathematical models of dynamic flow situations around impellers will be almost impossible. Theoretical models will probably be semi-empirical and based on available experimental data. Both areas will depend on the quality of information available from experience. Manufacturers and users should be encouraged to report on problems so that research is concentrated in areas relevant to the needs of the pumping industry.

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BOOK REVIEWS

BLAST VIBRATION MONITORING AND CONTROL

C.H. Dowding
Prentice-Hall, Inc.,
Inglewood Cliffs, NJ, 1985, 297 pages

The material covered in this book includes most aspects of the far-field effects of subsurface blasting with explosives and blasting agents. The topics are of concern to anyone interested in blasting damage or annoyance caused by blasting.

Following a general introduction that clearly and succinctly describes the purpose and scope of the book, the author covers, in short chapters, a variety of topics: ground-shock vibration characteristics, response spectra and structural response, estimation of structural dynamic response, air blast from blasting (including focusing effects), cosmetic cracking of structures, response of buried or earth-backed structures, machinery response, and human response. The last five chapters cover more technical aspects of blasting and ground shock measurement.

Including all of the above may seem ambitious, but the author has done an admirable job of covering topics in a logical and readable manner. He has emphasized physical effects and has used excellent figures and tables to illustrate his points. The mathematics is deliberately simple; response calculations are limited to response spectra and to damped, single-degree-of-freedom representations of structures. Reference to the literature is pertinent, thorough, and timely. Example problems provided throughout illustrate concepts and use of the relatively few equations presented in the text.

It is apparent that the author has had wide practical experience in the topics, as well as teaching experience. I can highly recommend this book for either a reader with direct interest in blasting and blasting effects or any engineer interested in reading about a complex topic that is presented clearly and understandably.

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MECHANICAL VIBRATIONS FOR ENGINEERS

M. Lalanne, P. Berthia, & J. der Hagopian
Translated by F.C. Nelson
John Wiley & Sons, New York, NY
1983, 266 pages

This is a revised and expanded version of a French text. The book stresses desk top computer applications and contains 12 computer programs written in BASIC. As stated by the authors, "This book is a basis for the study of linear, mechanical vibration. It is intended primarily for the use of students and practicing mechanical engineers. Its purpose is to provide an understanding of vibration phenomena and concepts, ability to formulate and solve equations of motion of vibrating systems and an appreciation of the role and technique of vibration measurements." Vibrations of structures are represented by structural models. Springs and masses, beams and plates, and simple structures employing finite elements and methods of substructure (component mode method) are given.

The book contains seven chapters, a short bibliography, an appendix describing Lagrange's equation, and more than 100 worked examples.

The first chapter considers the single-degree-of-freedom system (SDOF). Free and forced vibrations (harmonic and periodic excitation), damping, and a good explanation of Rayleigh's method and the transfer matrix are included, as is an example of applications of SDOF systems.

The next chapter is concerned with two-degree-of-freedom systems. Free and forced vibrations in both undamped and damped systems and a derivation of the vibration absorber are given. Chapter 3 has to do with N-degree-of-freedom systems. An explanation of matrix properties is followed by calculations of frequencies and modes using the Rayleigh-Ritz method and the iterative mode. The concluding section describes ways to calculate responses to excitation, including steady-state and general response.

Chapter 4 on continuous systems contains equations of motion for bars, rods, and beams (torsion and bending); frequency modes and orthogonality for longitudinal and lateral motions;

approximate methods (Rayleigh-Ritz); response to excitation; and the modal method and kinetic and strain energies of plates and rotor elements. Chapter 5 presents the finite element (FE) method and its application to dynamics. The equation is derived, as are stiffness and mass matrices; the elements are assembled into the complete FE. Frequencies, modes, and response to excitation; structural modification with application to the influence of a small structural modification; and use of either free modes or constrained modes in the component mode method as applied to structures are covered.

The topics of Chapter 6 are experimental methods and procedures used in vibration analysis. Included are transducers, piezoelectric strain gages, capacitive transducers (eddy-current and magnetic), exciters (electrodynamic and electrohydraulic), and measuring systems for sinusoidal excitation and spectral analysis.

Chapter 7 presents computer programs and describes the language used. Programs include steady-state response to SDOF systems, frequencies and modes of spring-mass and spring-mass-damper systems using the transfer matrix approach, frequency and mode calculation by the iteration method, steady-state response of a damped system subjected to sinusoidal excitation by the modal method, system response by the Wilson method, determination of a beam using both FE and transfer matrix methods, and an integral evaluation of the Gauss-Lagrange scheme for calculating a multiple integral by quadrature methods.

The reviewer feels that a number of additional topics should have been included. They are Dunkerly's method, Galerkin's method, Newmark's Beta method, and Houbolt's method used in transient response. Additional topics of interest that could be incorporated into a revised edition are experimental modal analysis and random vibration applied to beams and plates. The subspace iteration method used in FE would be an asset as would more detailed explanation and application of the data processing of spectral information.

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STANDARDS NEWS

Avril Brenig, Standards Manager

ASA Standards Secretariat, Acoustical Society of America, 335 East 45 Street, New York, New York 10017

William A. Yost
Parmly Hearing Institute, Loyola University of Chicago, 6525 North Sheridan Road, Chicago, Illinois 60626

American National Standards (ANSI Standards) in the areas of physical acoustics, bioacoustics, mechanical shock and vibration, and noise are published by the American Institute of Physics for the Acoustical Society of America (ASA). In addition to these standards, other Acoustical Society documents, a Catalog of Acoustical Standards—ASA Catalog 5-1984, and an Index to Noise Standards—ASA STDS Index 3-1985 (national and international) are available from the Standards Secretariat of the Acoustical Society. To obtain a current list of standards available from the Acoustical Society, write to Avril Brenig, at the above address. Telephone number: (212) 661-9404.

Calendar

The next meetings of the ASA standards committees are scheduled for 12–16 May 1986.

1986 May 12, ASA Committee on Standards, 7:30 p.m., The Bond Court, Cleveland, Ohio. Meeting of the Committee that directs the ASA Standards Program.

1986 May 14, Accredited Standards Committee S2 on Mechanical Shock and Vibration (also Technical Advisory Group for ISO/TC/108 and IEC/SC/50A), 2:00 p.m., The Bond Court, Cleveland, Ohio. Review of international and S12 activities and planning for future meetings.

1986 May 15, Accredited Standards Committee S12 on Noise (also Technical Advisory Group for ISO/TC43/SCl), 9:30 a.m. The Bond Court, Cleveland, Ohio. Review of international and S12 activities and planning for future meetings.

1986 May 15, Accredited Standards Committees Sl (Acoustics) and S3 (Bioacoustics) (also Technical Advisory Group for ISO/TC/43, IEC/TC/29, and IEC/TC108/SC4) at 1:30 p.m. The bond Court, Cleveland, Ohio. The S3 meeting will be held first. Review of S1, S3, and international standards activities and planning for future meetings.

Standards News from the United States

The following news items have been received since the last issue of *Standard News*:

Study evaluates OMB circular implementation

A policy that encourages federal government agencies to use voluntary standards in regulations and for procurement and to participate in their development went into effect in 1982. It was established by Office of Management and Budget Circular A-119. Has the policy been successfully implemented? Answers to this question are given in an analysis prepared by Dr. Steven M. Spivak, professor in the Department of Textiles and Consumer Economics at the University of Maryland.

Dr. Spivak concludes that implementation ranges from aggressive and effective, to emerging interest, to lack of interest. In general, he points out, regulatory agencies show lower participation and use of voluntary standards than procurement agencies.

The 73-page report assesses the impact of the Circular on both types of agencies and on standards developers and users in the private sector and analyzes factors responsible for the current status. Also included are recommendations on improving implementation.

Basis of the report are many interviews Dr. Spivak had with standards practitioners in the private and public sectors. A prolog contains selected quotations. His study was commissioned by the Office of Product Standards Policy, National Bureau of Standards, as an independent appraisal. Later this year the secretary of commerce is scheduled to submit a formal triennial report on implementation of A-119 to the Office of Management and Budget.

Quality assurance conference held by ANSI, DoD, and GSA

Ways and means of assuring high-quality products and services through the use of standards and related mechanisms were explored at a 23 October 1985 conference sponsored by the American National Standards Institute, Department of Defense, and the General Services Administration. The meeting was held in the Washington, DC, area—at the Radisson Mark Plaza Hotel in Alexandria, Virginia.

A U. S. senator and top-level executives from DoD, GSA, and industry were among the speakers.

Senator Dan Quayle was the luncheon speaker. He is chairman of the Subcommittee on Procurement of the Senate Armed Services Committee.

Dr. James P. Wade, Jr., of DoD and Donald C. J. Gray of GSA detailed how government is using standards to improve and maintain high quality. Dr. Wade is assistant secretary of defense for acquisition and logistics. Mr. Gray is assistant administrator of GSA's Office of Federal Supply and Services.

An industry perspective was provided by John D. Rittenhouse, executive vice-president, aerospace and defense, RCA Corporation.

How government procurement agencies and industry handle quality and standards problems were discussed by two panels at an afternoon session. Panelists from DoD and GSA included two executives from the Office of the Under Secretary of Defense (Research and Engineering). They were Peter Yurcisin, director, standardization and acquisitions; and R. Richard Stimson, director, industrial productivity. On the agenda was a review of DoD's "streamlining" program and "Computer Aided Logistic Support (CALS)" program.

What the private sector is doing to make industry standards compatible with government standards was one of the topics discussed by the industry panel.

The 23 October Conference on Quality Assurance and Standards was opened by Edward J. Zillian, chairman of ANSI's Company Member Council and manager of government-industry relations, AT&T Technologies.

Both the Department of Defense and the General Services Administration, the business arm of the federal government, are major purchasers of goods and services and rely heavily on standards in procurement.

Meeting set on DoD adoption of standards

A conference on Department of Defense adoption of industry standards will be held 4–5 December 1985, at the Williamsburg Hilton National Conference Center in Virginia. It sponsors are DoD, the Society of Automotive Engineers, and ASTM.

The meeting will feature presentations by key military personnel and representatives from industry and standards developing organizations. Also scheduled are panel discussions on such subjects as: the coordination of revisions to DoD-adopted industry standards; DoD participation in industry committees; increased development by private-sector groups of product specifications; and the use by the DoD of such specifications in formulating its Qualified Products List.

Recommendations made by the panel are expected to influence future DoD policies.

J. Acoust. Soc. Am. 78(5), Nov. 1985 0001-4966/85/111917-02$00.80

For additional program or registration information, contact Darlene Filler or David Bentley at SAE Headquarters, 400 Commonwealth Drive, Warrendale, PA 15096, (412) 776-4841.

J. G. O'Grady becomes ASTM's new president

Joseph G. O'Grady has been appointed president of ASTM. In this position he will direct a staff that serves the needs of 140 technical committees and 30 000 members who develop voluntary consensus standards for materials, products, and systems.

Mr. O'Grady joined ASTM's staff in 1984 as executive vice-president. Earlier, as a volunteer, he served on the organization's Board of Directors for 8 years. From 1978–1979, he was board chairman.

Prior to 1984, Mr. O'Grady was vice-president of PSE&G Research Corporation, a subsidiary of Public Service Electric and Gas Company of New Jersey.

Mr. O'Grady is a member of the Industry Functional Advisory Committee on Standards for Trade Policy Matters. Since 1979 he has served on the National Executive Committee of the Consultative Council of the National Institute of Building Sciences. Other organizations he served include the American Association of Laboratory Accreditation, the Edison Electric Institute, and the Institute of Electrical and Electronics Engineers. He is a former director of AALA and former chairman of the Executive Advisory Committee of EEI's Codes and Standards Committee

Mr.O'Grady is a graduate of New York University.

Standards News from Abroad

The following news items have been received since the last issue of *Standards News:*

IEC world standard for integrated-averaging sound level meters

A new world standard which will help solve the problem of accurately measuring noise pollution levels in industry and in the community will soon be available from the IEC.

The standard will cover the accuracy and stability of an integrating sound level meter and aims to reduce to a practical minimum any difference in equivalent measurements taken with instruments of various makes and models.

The standard specifies integrating sound level meters of four degrees of accuracy, designated types 0, 1, 2, and 3. The standard specifies the following characteristics and test methods for integrating sound level meters: integrating and averaging characteristics; indicator characteristics; and overload sensing and indicating characteristics.

Integrating sound level meters should also comply with the requirements in IEC Publication 651: Sound level meters, as regards directional characteristics, frequency weighting characteristics, and sensitivity to various environments.

The type 0 integrating sound level meter is intended as a laboratory reference standard. Type 1 is intended for laboratory use and for field use where the acoustical environment can be closely specified and/or controlled. The type 2 integrating sound level is suitable for general field applications. Type 3 is intended primarily for field noise survey applications.

Standards approved by ANSI and published by ASA

The following standards were approved and published by ASA:

ANSI S1.6-1984	Preferred Frequencies, Frequency Levels, and Band Numbers for Acoustical Measurement (revision and redesignation of ANSI S1.6-1967)
ANSI S1.40-1984	Specifications for Acoustical Calibrators
ANSI S2.34-1984	Experimental Determination of Rotational Mobility Properties and the Complete Mobility Matrix, Guide to
ANSI S12.6-1984	Real-Ear Attenuation of Hearing Protectors, Method for the Measurement of the (revision and redesignation of ANSI S3.19-1974)
ANSI S2.40-1984	Mechanical Vibration of Rotating Machinery—Requirements for Instruments for Measuring Vibration Severity
ASA STDS INDEX 3-1985	Index to Noise Standards, 3rd Edition
ANSI S3.35-1985	Methods of Measurement of Performance Characteristics of Hearing Aids under Simulated *In Situ* Working Conditions
ANSI S3.36-1985	Methods for Simulated *In Situ* Airborne Acoustic Measurements
ANSI S12.3-1985	Stated Noise Emission Values of Machinery and Equipment. Statistical Methods for Determining and Verifying
ANSI S1.30-1979(R1985)	Guidelines for the Use of Sound Power Standards and for the Preparation of Noise Test Codes
ANSI S1.35-1979(R1985)	Precision Methods for the Determination of Sound Power Levels of Noise Sources in Anechoic and Hemi-Anechoic Rooms
ANSI S1.36-1979(R1985)	*Survey Methods for the Determination of* Sound Power Levels of Noise Sources

The above standards are available from the Standards Secretariat at the following address: AIP Publication Sales Department, Department STD, 335 East 45th Street, New York, NY 10017. (A 20% discount is available to individual and sustaining members of the Society.)

International documents on acoustics received in the United States

The documents listed below have been received by the Standards Secretariat of the Society and have been announced to S1, S2, S3, or S12. The document is listed to the left of each document and the Accredited Standards Committee to which the document was announced is listed in parentheses below the document number. Further information on each document can be obtained from the Standards Secretariat.

The following documents have been received from ISO for vote:

ISO/DIS 7566 (S3)	Acoustics—Standard reference zero for the calibration of pure-tone bone-conduction audiometers
ISO/DIS 8253 (S3)	Acoustics—Pure-tone audiometric test methods
ISO/DIS 7962 (S3)	Vibration and Shock—Mechanical transmissibility of the human body
ISO/389 DAD 2 (S3)	Acoustics—Standard Reference zero for the calibration of pure-tone air conduction audiometers
ISO/DP 8297 (S12)	Determination of sound power levels of multisource industrial plants for the evaluation of the sound pressure levels in the environment—Engineering method
ISO/DIS 3989/1 (S12) Part 1:	Acoustics—Measurement of airborne noise emitted by compressor units including prime movers Engineering method for determination of sound power levels
ISO/DIS 3989/2 (S12) Part 2:	Acoustics—Measurement of airborne noise emitted by compressor units including prime movers *Method for checking compliance with noise limits*
ISO/DIS 3481/1.2 (S12) Part 1:	Acoustics—Measurement of airborne noise emitted by pneumatic tools and machines Engineering method for determination of sound power levels
ISO/DIS 3481/2.2 (S12) Part 2:	Acoustics—Measurement of airborne noise emitted by pneumatic tools and machines Method for checking compliance with noise limits
ISO/DIS 7779 (S12)	Acoustic measurement of airborne noise emitted by computer and business equipment

The following documents have been received from ISO for comment:

ISO/DP 8727-ISO/TC 108/SC4 N 150 (S2)	First draft proposal on standard and biodynamic coordinate systems
ISO/DP 8798 (S3)	Acoustics—Reference levels for narrow-band masking

The following documents have been received from IEC for comment:

IEC/SC 29C (Central Office) 52 (S3)	Audiometers, Part 1: Pure-tone audiometers (Revision of IEC 645)

S3 meets in Austin

Standards Committee S3, Bioacoustics, met in Austin, Texas on 11 April 1985. The following reports of the working groups are submitted by the chair of S3, Laura Wilber.

S3-35 Audiometers—*R. Grason, Chair*

Mr. Grason was not in attendance. However, he had reported that the revised text of proposed ANSI standard S3.6-198X on Audiometers was sent to S3 letter ballot on 24 January 1985. The ballot was extended to 4 April 1985 to accommodate receipt of additional outside comments. That ballot resulted in 11 affirmative and 2 negative votes. Mr. Grason is in the process of trying to resolve the negative votes.

S3-36 Speech Intelligibility—*J. Webster, Chair*

Mr. Webster was not present, but he had reported that a draft standard prepared by S3-36/1 (chaired by V. Beyers) S3.31-198X on methods for determining the threshold level for speech which had been sent for ballot in 1983 was still being discussed in an attempt to resolve the negative votes.

S3-37 Coupler Calibration of Earphones—*M. D. Burkhard, Chair*

Mr. Burkhard reported that there was need for work on revision of ANSI S3.25-1979.

S3-39 Human Exposure to Mechanical Vibration and Shock—*H. E. von Gierke, Chair*

Mr. von Gierke reported that resolutions of the SC4 meeting held in Edinburgh in September 1984 are available from the Standards Secretariat. The ANSI Standard Guide to the Evaluation of Human Exposure to vibration in Buildings (S3.29-1983) was published.

S3-43 Method for Calibration of Bone Conduction Vibrators—*D. Dirks, Chair*

Mr. Dirks had reported that the working group is preparing a revision of ANSI S3.13-1972 (R 1977) on Artificial Head Bone for Calibration of Audiometer Bone Vibrators. The draft should be ready for ballot shortly and will essentially parallel the IEC Standard (IEC 373).

S3-48 Hearing Aids—*D. A. Preves, Chair*

A draft standard, (S3.35-198X) Methods of Measurement of Performance Characteristics of Hearing Aids under Simulated *in situ* Working Conditions was sent to S3 ballot on 1 November.

Other items under study are: correction factors for coupler measurements and standardized plugs for electrical inputs to hearing aids. Mr. Preves also reported that the hearing aid standards were reviewed and that a round robin on compression is being carried out. Further, there has been discussion on comparing test results for in-the-ear hearing aids on the 2-cc coupler, the Zwislocki ear simulator and KEMAR.

S3-54 Biological and Medical Ultrasound—*J. A. Rooney, Chair*

Mr. Rooney had reported that the AIUM Standard was being prepared for ballot.

S3-56 Criteria for Background Noise for Audiometer Testing—*G. Studebaker, Chair*

It is planned that S3.1-1977 will be reviewed with a view toward clarifying the circumstances wherein program goals can be met by testing at levels higher than 0 dB HL. (For example, in screening audiometry, it is often not necessary to test at such faint levels.)

S3-58 Hearing Conservation Criteria—*J. Tonndorf, Chair*

Mr. von Gierke reported that the international standard (ISO 1999) has been approved as an ISO standard. However, this document will be recirculated by ISO in order to meet comments from the French Member Body of ISO/TC 43.

S3-59 Measurements of Speech Levels—*K. Pearsons, Chair*

There was some discussion of a draft standard on speech levels which has not yet been circulated. It is hoped that with the consideration of new sources of data, that the standard will be evaluated, and that it will be ready for circulation.

S3-60 Measurement of Acoustic Immittance of the Ear—*D. Lilly, Chair*

This working group will consider the activities of the new IEC working group on "Acoustic Impedance Measuring Instruments used in Audiology" while drafting its standard.

During this meeting, Mr. Young stated that the title of the working group represented terminology that is not currently used in Europe. Following discussion, and on motion made and seconded it was voted to change the title of the S3-60 working group to *Measurement of Acoustic Impedance and Admittance of the Ear.* A ballot on this motion will be circulated to the entire membership of S3.

S3-61 Sound Pressure Distribution Around the Head and Torso—*G. Kuhn, Chair*

The paper on sound pressure distribution around the human head and torso has been accepted for publication. The group believes it has completed its task and recommends its disbandment. This proposal will be circulated for ballot of S3.

S3-62 Impulsive Noise with Respect to Hearing Hazard—*D. Johnson, Chair*

A revised document, S3.28-198X, on Standard Methods for the Evaluation of the Potential Effect on Human Hearing of Sound with Peak A-weighted Sound Pressure Levels above 120 decibels and peak C-weighted Sound Pressure Levels below 140 decibels was balloted in 1983. A revised text was sent to 30-day review of S3 on 12 November 1984. The final results showed eight (8) unresolved objections to the proposed ANSI Standard. The chair of this group will attempt to resolve the remaining negative votes and then resubmit the document to S3.

S3-63 Acoustical Warning Devices—*M. Whitcomb, Chair*

The document ISO/DP 8201 was submitted to ISO for issuance as a Draft International Standard. To date it has not been circulated. There was also continued discussion as to whether the words *auditory warning signals* should be included in the scope of S3 since it has been revealed that the lack of coordination by ANSI has resulted in three other standards on this same subject.

S3-67 Manikins—*M. D.Burkhard, Chair*

Mr. Burkhard reports that work is proceeding on a draft document on head and torso simulators within IEC/SC29C/WG13. He further reported that the proposed American National Standard Specification for a Manikin for Simulated *in situ* Airborne Acoustic Measurements (S3.36-198X) was circulated for ballot to S3. There were 14 affirmative and 0 negative votes.

S3-68 Auditory Magnitudes

It was recommended that this group which has no charge and no chair be disbanded. This proposal will be circulated to the members of S3 for vote.

S3-69 Auditory Trainers—*S. Sinclair, Chair*

It was reported that an initial draft document is being prepared. It was recommended that this group interface with S3-48 (Hearing Aids) to make sure there are no substantial conflicts. Ms. Wilber will attempt to contact Mr. Sinclair to determine the status of this document.

S3-71 Artificial Mouths—*R. Sachs, Chair*

Mr. Sachs had reported that the groups membership list has been updated, and that further discussion of the issues and need for investigation will be considered. A specific charge for the reconstituted group has been developed and will be circulated to S3 for vote.

S3-72 Brainstem Evoked Responses—*R. A. Ruth, Chair*

Mr. Ruth has reported that the group is in the process of developing a working draft of a document describing the stimulus characteristics necessary for AEP measurements.

S3-73 Bioacoustical Terminology—*H. Silberger, Chair*

Mr. Silberger has requested that *all* chairs of working groups send him a list of terms in the drafts for development as standards, as well as terminology already in existing standards, which should be included in the bioacoustical terminology standard. He further reports that other suggestions are being sought and that he would welcome specific suggestions with rationale for their use.

S3-75 Auditory Masking—*S. Buus, Chair*

This is a new working group which met for the first time in Minneapo-

lis. Its scope has been redefined and is being sent out to the members of S3 for vote.

S3-76 Computerized Audiometry—*C. Wier, Chair*

This is a new working group. It's scope is standardization of computer applications to audiometry, including automated psychophysical procedures. A list of members is being prepared.

S3-77 High Frequency Audiometry—*J. Fletcher, Chair*

This new working group met in Austin and has begun drafting a standard for high-frequency audiometry.

S3-78 Thresholds—*W. Yost, Chair*

This is a new working group designed to provide a liaison with ISO, IEC, and other national working groups for standards dealing with auditory thresholds and procedures to measure these thresholds.

S3-79 Calculation of the Articulation Index—*C. V. Pavlovic, Chair*

This new working group is a continuation of the activity previously in the working group on speech levels and is in the process of preparing the revision of ANSI S3.5-1969 (R 1978), Methods for the Calculation of the Articulation Index. Mr. Pavlovic reported that the working group has met twice and anticipates a year of work.

S12 meets in Austin

Ken Eldred, Chairman, has submitted the status report of S12, Noise. The committee met in Austin, Texas during the Spring Meeting of the Acoustical Society held in April 1985.

S2-1 Advisory Planning Committee—*W. Melnick, Chair*

As a result of proposals by the planning committee, at the last meeting, an S12 ballot was circulated on 5 December 1984 and closed on 2 January 1985. The items below were approved and implemented accordingly.

(a) Formation of working group S12-25 Noise Labeling; (b) Appointment of H. E. von Gierke as S12 TAG Chairman for ISO/TC 94/SC 12 Hearing protection; (c) revision in Scope of S12-23 Determination of Sound Power.

S12-2 Terminology, Abbreviations and Symbols—*R. K. Hillquist, Chair*

An initial listing of candidate terms is being formulated and liaison has been established with ASC Y10, Letter Symbols.

It was agreed previously that Mr. Hillquist should proceed to develop a document on terminology for S12 as soon as possible. Questions of liaison and/or overlap with other areas of terminology could be taken care of at a later date.

S12-3 Measurement of Noise from Office and Data Processing Equipment—*L. Luttrell, Chair*

Proposed ANSI S12.10-198X, a revision of ANSI S1.29-1979 Methods for the Measurement and Designation of Noise emitted by Computer and Business Equipment (draft dated June 1984), was sent to S12 ballot on 28 January 1985. The ballot was closed on 11 March 1985, with results as given in the minutes.

At the meeting, Mr. Luttrell reported that the document is being revised in accordance with the comments received and the new text should be ready for 30-day review within three months.

S12-6 Insertion Loss of Outdoor Noise Barriers at Sites of Interest—*W. Bowlby, Chair*

Mr. Bowlby reported as follows at the meeting:

Draft No. 6 was completed and distributed to the working group and discussed at our 10 April meeting. The completion date for the U.S. Department of Transportation contract was extended to 30 September 1985, but we plan to ask for another extension, at no cost to the Government, to the end of 1985. The Federal Highway Administration plans to do a major field evaluation at a test site this summer. We expect to be ready for ballot by the end of the year. The title of the standard has been revised as follows: "American National Standard Methods for Determination of Insertion loss of Outdoor Noise Barriers."

S12-7 Statistical Sampling Procedures for Noise Emission Requirements—*L. Luttrell, Chair*

Proposed American National Standard S12.3-198X Statistical Methods for Determining and Verifying State Noise Emission Values of Machinery and Equipment (revised draft dated October 1984) was circulated to S12 on 12 December 1984.

No negative vote was received as a result of this circulation and the proposed standard was submitted to ANSI for formal approval in March 1985. (The standard was approved by ANSI on 24 May 1985.)

S12-8 Determination of Interference of Noise with Speech Intelligibility—*M. J. Collins, Chair*

Ms. Collins reported as follows:

The S12-8 working group will meet in November 1984 (at ASHA meeting in San Francisco) to determine potential data basis for expansion of the S12 curves for various values of reverberation.

S12-9 Annoyance Response to Impulsive Noise—*L. Sutherland, Chair*

The document, "Method for Assessment of High Energy Impulse Sounds with Respect to Residual Communities," was submitted to S12 ballot on 1 July 1983. The ballot closed on August 1983 with results as reported previously.

At the last meeting, it was decided that the document should be sent to a 30-day review of S12, with whatever negative comments are still unresolved. The 30-day review is being prepared for circulation to S12 voting members shortly.

S12-10 Hearing Protector Attenuation—*C. Nixon, Chair*

ANSI S12.6-1984 Method for the Measurement of the Real-Ear Attenuation of Hearing Protectors, was approved by ANSI on 17 December 1984 and published by ASA.

S12-12 Evaluation of Hearing Conservation Programs—*L. Royster, Chair*

Mr. Royster reported at the meeting as follows:

The S12.12 working group held a regular meeting on 10 April 1985 in Austin, Texas during the Spring meeting of ASA. The meeting was attended by 8 of the 14 committee members. The chairman announced that the committee had been promised 21 audiometric data bases and that four of the data bases had been received. The chairman noted that he had not received any responses to his request that members of the committee submit potential audiometric data base analysis procedures to the committee prior to the Austin ASA meeting. The committee suggested that a second notice be mailed to the membership reminding them of the committee's desire to identify potential audiometric data base analysis procedures for consideration by the committee. The chairman announced that 1 June 1985 would be the last date for members of the committee to submit an acceptable audiometric data base to the committee. The chairman also announced that the next meeting of the committee, to be held during the Fall meeting of ASA in Nashville, Tennessee, would be a very important meeting of the committee in that the consideration of potential audiometric data base analysis procedures would be the main item on the agenda. At the Austin meeting, Georgia Holmes (Audiologist at Alabama Power and Light) was introduced as a new member to the S12.12 working group.

S12-13 Community Response to Noise Levels—*F. Hall, Chair*

The working group is in general agreement on the outline for a proposed standard. Mr. Hall reported that he expected to have an opportunity in the forthcoming year to work on the standard while he is on sabbatical leave and working at the University California.

S12-15 Measurement and Evaluation of Outdoor Community Noise—*P. Schomer, Chair*

A draft standard was prepared and submitted to S12 for ballot on 16 April 1984. The ballot closed on 1 June 1984, with results as given in the last minutes. A revised document was prepared for S12 ballot and circulated on 22 February 1985. The ballot was closed on 17 April 1985, results as given in the minutes. There is a move toward the direction of TC 43/SC 1/WG 20 in the national activity.

S12-18 Criteria for Room Noise—*S. L. Yaniv, Chair*

The proposed draft ANSI Standard Procedure for Measuring and Rating Steady-State Room Noise was submitted to ballot on 22 September 1982. The ballot closed on 3 November 1982 with results as given previously.

Ms. Yaniv reported that she hoped to have draft Number 6 available (as well as supporting paper) for ballot before the Fall 1985 meeting.

S12-19 Measurement of Occupational Noise Exposure—*J. P. Barry/W. Thornton, Co-Chairs*

The new charge to ISO/TC 43/SC1 (which developed ISO 1999), i.e., to produce a standard on noise at the workplace, which would be comprehensive, was discussed previously. Factors to be included are noise, annoyance, and other nonauditory health effects at the workplace. It was suggested previously that this working group could be the national counterpart for the international activity.

Mr. Thornton has circulated a draft of the proposed standard on Measurement of Occupational Noise Exposure to the working group. It should be available for ballot in S12 shortly. At the last meeting, it was agreed that it would be helpful to circulate a questionnaire on this subject. Mr. Thorn-

ton also mentioned the need for guidance on what units to use to measure the loss of hearing.

S12-20 Specification of the New Machinery at the Operator's Position—*R. D. Bruce, Chair*

The initial activity of this working group is being defined and will be reported on at the next S12 meeting.

S12-21 Determination of Sound Power using Sound Intensity Measurements—*M. J. Crocker, Chair*

Mr. Krishnappa reported that a document is being prepared and that the work was being conducted in parallel with ISO/TC 43/SC 1.

S12-22 Impulse Sound Propagation for Community Noise Assessment—*R. Raspet, Chair*

Mr. Raspet reported prior to the meeting as follows:

The effect of mountains and hills on blast noise propagation has been investigated and boundary conditions have been determined for calculation of engineering estimates of propagation over such terrain.

At the meeting Mr. Young questioned the appropriateness of this activity. Following discussion and recommendations from Messrs. Gales and Sutherland, it was proposed that the title of S12-22 be changed from Impulse Sound Propagation for Community Noise Assessment to Impulse Sound Propagation for *Environmental* Noise Assessment.

Discussion centered on whether propagation belonged in this case in S1. There was basic disagreement to this suggestion since the limits *re*: noise make for a more limited scope than a basic standard on sound propagation. Accordingly, it was VOTED that the title of S12-22 should be changed from Impulse Sound Propagation for Community Noise Assessment to Impulse Sound Propagation for Environmental Noise Assessment. The motion carried with three negatives (Benson, Peppin, and Young) and was proposed for vote of S12 following the meeting. Following this motion, and discussion of the fact that there can be no vote without clarification of scope of the working group, it was VOTED to table the above motion until clarification of the scope of the working group exists.

S12-23 Determination of Sound Power—*P. K. Baade, Chair*

This working group will monitor the sound power series of standards (i.e., S1.30, 31, 32, 33, 34, 35, and 36) and complete the development of S1.37 and S1.38 (the latter to have S12 numbers).

The proposed ANSI Standard, S12.5-198X, Determination of Sound Power Levels of Noise Sources—Characterization and Calibration of Reference Sound Sources, Draft dated June 1983, was sent to ballot on 30 June 1983. (It is the counterpart to ISO/DIS 6926.) All negative votes have now been resolved and the revised document sent to 30-day review of voting members of S12.

Good progress is being made on the revision of ANSI S1.34-1980 Methods for the Determination of Sound Power Levels of Noise Sources for Essentially Free-Field Conditions over a Reflecting Plane.

S12-24 Placement of Personal Noise Monitoring Microphones—*A. Burks, Chair*

This is a new working group chaired by Mr. Burks.

S12-25 Noise Labeling—*P. K. Baade/R. S. Gales, Co-Chairs*

Co-chairs have been appointed for this working group. They are Messrs. P. K. Baade and R. S. Gales.

S12-26 Hearing Protector Characteristics—*E. Berger, Chair*

Mr. Berger has reported as follows:

ISO TC94/SC12 first met in Manchester, England in November 1983 at which time the U.S. was neither a "P" nor "O" member. Since that time the U.S. has become a "P" member and Elliott Berger attended the second meeting of SC12 held in Helsinki, Finland in September 1984. The next meeting is tentatively planned for Spring, 1986.

A draft of a document specifying physical and performance characteristics for earmuffs was prepared in Manchester. Accompanying documents for earplugs and an appendix on selection, use, and care are planned. The earmuff draft document and the selection, use, and care draft document were reviewed in Helsinki. A working group (WG1) was set up to define some of the testing particulars. Mr. Berger is also a member of the WG.

S12-26 was formed as a counterpart to SC12 and will be the vehicle used to develop the U.S. position on the proposed documents. When the next draft is received for comment it will be circulated amongst the active membership of S12-10 as well as other interested parties. If necessary, a meeting will be called in conjunction with a future ASA meeting in order to coordinate the U.S. position.

Documents without working groups submitted to S12 Ballot

The document entitled Standard Methods for the Measurement of Impulse Noise, S12.7-198X, was formerly under the jurisdiction of S1 and designated as S1.28. It was revised and submitted to S12 ballot (and to S1 for information) on 15 March 1984. Discussions and meetings were held to address comments stemming from this ballot. A revised document has been prepared for 30-day review by S12 voting members and will be circulated shortly.

Report on International Matters

S12 has been assigned TAG responsibility for a new Subcommittee in ISO, TC 94/SC12 on Hearing Protection (under the new ISO Technical Committee TC 94 on Safety). Mr. von Gierke has been appointed TAG Chairman for ISO/TC 94/SC 12.

SHORT COURSES

FEBRUARY

VIBRATION AND SHOCK SURVIVABILITY, TESTING, MEASUREMENT, ANALYSIS, AND CALIBRATION

Dates: February 3-7, 1986
Place: Santa Barbara, California
Dates: March 10-14, 1986
Place: Washington, DC
Dates: May 12-16, 1986
Place: Detroit, Michigan
Dates: June 2-6, 1986
Place: Santa Barbara, California
Dates: August 18-22, 1986
Place: Santa Barbara, California
Objective: Topics to be covered are resonance and fragility phenomena, and environmental vibration and shock measurement and analysis; also vibration and shock environmental testing to prove survivability. This course will concentrate upon equipments and techniques, rather than upon mathematics and theory.

Contact: Wayne Tustin, 22 East Los Olivos Street, Santa Barbara, CA 93105 -(805) 682-7171.

COMPUTER SIMULATION OF HIGH VELOCITY IMPACT

Dates: February 10-13, 1986
Place: San Diego, CA
Objective: This course is designed for engineers and scientists requiring a knowledge of the capabilities of production computer codes for the description of the dynamic behavior of solids and explosives whose loadings and response times are in the sub-millisecond regime. The course features tutorial lectures covering essentials of high velocity impact phenomena, material behavior at high strain rates, computational material models, failure descriptions, a survey of computer codes for wave propagation and penetration problems and simulation of explosive behavior with reactive hydrodynamic codes.

Contact: Computational Mechanics Associates, P.O. Box 11314, Baltimore, MD 21239 - (301) 435-1411.

MACHINERY MONITORING

Dates: February 11-13, 1986
Place: Houston, Texas
Dates: February 25-27, 1986
Place: Tampa, Florida
Dates: April 22-24, 1986
Place: Philadelphia, Pennsylvania
Dates: May 20-22, 1986
Place: Chicago, Illinois
Dates: June 10-12, 1986
Place: Anaheim, California
Objective: The seminar focuses on the principles of vibration measurement for rotating machinery monitoring. Subjects covered in the seminar include troubleshooting, calibration and maintenance of monitoring systems, and the applications and installation of displacement, velocity, and acceleration transducers.

Contact: Bently Nevada's Customer Information Center, P.O. Box 157, Minden, NV 89437 -800-227-5514, Ext. 9682.

MACHINERY VIBRATION ANALYSIS I

Dates: February 11-14, 1986
Place: Orlando, Florida
Dates: August 19-22, 1986
Place: New Orleans, Louisiana
Dates: November 11-14, 1986
Place: Chicago, Illinois
Objective: This course emphasizes the role of vibrations in mechanical equipment instrumentation for vibration measurement, techniques for vibration analysis and control, and vibration correction and criteria. Examples and case histories from actual vibration problems in the petroleum, process, chemical, power, paper, and pharmaceutical industries are used to illustrate techniques. Participants have the opportunity to become familiar with these techniques during the workshops. Lecture topics include: spectrum, time domain, modal, and orbital analysis; determination of natural frequency, resonance, and critical speed; vibration analysis of specific mechanical components, equipment, and equipment trains; identification of machine forces and frequencies; basic rotor dynamics including fluid-film bearing characteristics, instabilities, and response to mass unbalance; vibration correction including balancing; vibration control including isolation and damping of installed equipment;

selection and use of instrumentation; equipment evaluation techniques; shop testing; and plant predictive and preventive maintenance. This course will be of interest to plant engineers and technicians who must identify and correct faults in machinery.

Contact: Dr. Ronald L. Eshleman, Director, The Vibration Institute, 101 West 55th Street, Suite 206, Clarendon Hills, IL 60514 - (312) 654-2254.

SHAFT CRACK DETECTION
Dates: February 18-20, 1986
Place: Atlanta, Georgia
Objective: The seminar will cover a number of subjects, including vibration measurement transducer applications, filters for shaft crack detection, data presentation formats, rotor mode shape identification, shaft crack documentation, on-line crack detection method, and transient crack detection method. Case histories will be presented on shaft crack detection on a vertical pump, radial cracking on a turbine generator shaft, spiral cracking on a turbine generator shaft, detection of a shaft crack on a boiler feed pump, and laboratory testing results on shaft crack detection. Workshops on mode shape identification, shaft crack detection, and effects of shaft cracks on balancing will also be featured.

Contact: Bently Rotor Dynamics Research Corp., P.O. Box 157, Minden, NV 89423 -800-227-5514, Ext. 9682.

DYNAMIC BALANCING
Dates: February 19-20, 1986
April 23-24, 1986
June 18-19, 1986
Place: Columbus, Ohio
Objective: Balancing experts will contribute a series of lectures on field balancing and balancing machines. Subjects include: field balancing methods; single, two and multi-plane balancing techniques; balancing tolerances and correction methods. The latest in-place balancing techniques will be demonstrated and used in the workshops. Balancing machines equipped with microprocessor instrumentation will also be demonstrated in the workshop sessions, where each student will be involved in hands-on problem-solving using actual armatures, pump impellers, turbine wheels, etc., with emphasis on reducing costs and improving quality in balancing operations.

Contact: R.E. Ellis, IRD Mechanalysis Inc., 6150 Huntley Road, Columbus, OH 43229 -(614) 885-5376.

MARCH

MEASUREMENT SYSTEMS ENGINEERING
Dates: March 10-14, 1986
Place: Phoenix, Arizona
MEASUREMENT SYSTEMS DYNAMICS
Dates: March 17-21, 1986
Place: Phoenix, Arizona
Objective: Electrical measurements of mechanical and thermal quantities are presented through the new and unique "Unified Approach to the Engineering of Measurement Systems." Test requestors, designers, theoretical analysts, managers and experimental groups are the audience for which these programs have been designed. Cost-effective, valid data in the field and in the laboratory, are emphasized. Not only how to do that job, but how to tell when it's been done right.

Contact: Peter K. Stein, Director, 5602 East Monte Rosa, Phoenix, AZ 85018 - (602) 945-4603; (602) 947-6333.

MACHINERY DIAGNOSTICS
Dates: March 11-14, 1986
Place: San Francisco, California
Dates: March 17-21, 1986
Place: Carson City, Nevada
Dates: April 8-11, 1986
Place: Atlanta, Georgia
Dates: May 5-9, 1986
Place: Carson City, Nevada
Dates: June 16-20, 1986
Place: Carson City, Nevada
Dates: June 24-27, 1986
Place: Denver, Colorado
Objective: This seminar instructs rotating machinery users on transducer fundamentals, the use of basic diagnostic techniques, and interpreting industry-accepted vibration data formats to diagnose common rotating machinery malfunctions. The seminar includes class demonstrations, case histories, and a hands-on workshop that allows participants to diagnose malfunctions on demonstrator rotor systems.

Contact: Bently Nevada's Customer Information Center, P.O. Box 157, Minden, NV 89437 - 800-227-5514, Ext. 9682.

EXPLOSIVE SHOCKS IN AIR
Dates: March 17-21, 1986
Place: Monterey, CA
Objective: This course presents the theoretical and practical aspects of blast and shock waves

generated by explosions in air and of their damage capability. Major topics covered in the course include the nature of explosions, thermodynamics of explosions, the shock front, reflected shocks, blast waves, explosion overpressures, scaling laws, dynamic blast loads on structures and structural response to blast loading. The course is intended for engineers and scientists requiring a solid foundation in the subject area. It has been designed as an introductory course and is therefore ideally suited to those new to the area.

Contact: Computational Mechanics Associates, P.O. Box 11314, Baltimore, MD 21239 - (301) 435-1411.

APRIL

FUNDAMENTAL ASPECTS OF HYPERVELOCITY IMPACT AND SHAPED-CHARGE PHENOMENA

Dates: April 7-11, 1986
Place: Baltimore, MD
Objective: The course is designed for novices in the field of hypervelocity impact. It will provide a basic introduction to theoretical and experimental aspects of hypervelocity impact, including shaped-charge phenomena. Major topics to be covered include: physics of explosives; fundamentals of shaped-charges; explosive/metal interaction; analytical penetration and hole growth models; experimental techniques in hypervelocity impact studies; computational aspects of hypervelocity impact and shaped-charges.

Contact: Computational Mechanics Associates, P.O. Box 11314, Baltimore, MD 21239 - (301) 435-1411.

MACHINERY VIBRATION ANALYSIS II

Dates: April 28 - May 2, 1986
Place: Syria, Virginia
Objective: The objective of this course is to expose participants to advanced techniques of vibration analysis using single-and dual-channel FFT analyzers. These techniques include analysis of spectrum, time, frequency, and orbital domain; modal analysis; coherence, frequency response functions, and synchronous time averaging; and amplitude, phase, and frequency modulation. Data processing procedures are reviewed. All techniques are illustrated with examples and case histories of industrial machinery. Instrumentation necessary to implement the techniques is available for use by participants during informal workshops; taped data from actual industrial machinery are used during these workshops.

Contact: Dr. Ronald L. Eshleman, Director, The Vibration Institute, 101 West 55th Street, Suite 206, Clarendon Hills, IL 60514 - (312) 654-2254.

MAY

ROTATING MACHINERY VIBRATIONS

Dates: May 19-21, 1986
Place: Orlando, Florida
Objective: This course provides participants with an understanding of the principles and practices of rotating machinery vibrations and the application of these principles to practical problems. Some of the topics to be discussed are: theory of applied vibration engineering applied to rotating machinery; vibrational stresses and component fatigue; engineering instrumentation measurements; test data acquisition and diagnosis; fundamentals of rotor dynamics theory; bearing static and dynamic properties; system analysis; blading analysis; life estimation; practical rotor blading-bearing dynamics examples and case histories; rotor balancing theory; balancing of rotors in bearings; rotor signature analysis and diagnosis; and rotor-bearing failure prevention.

Contact: Dr. Ronald L. Eshleman, Director, The Vibration Institute, 101 West 55th Street, Suite 206, Clarendon Hills, Il 60514 - (312) 654-2254.

APPLIED VIBRATION ENGINEERING

Dates: May 19-21, 1986
Place: Orlando, Florida
Objective: This intensive course is designed for specialists, engineers and scientists involved with design against vibration or solving of existing vibration problems. This course provides participants with an understanding of the principles of vibration and the application of these principles to practical problems of vibration reduction or isolation. Some of the topics to be discussed are: fundamentals of vibration engineering; component vibration stresses and fatigue; instrumentation and measurement engineering; test data acquisition and diagnosis; applied spectrum analysis techniques; spectral analysis techniques for preventive maintenance; signal analysis for machinery diagnostics; random vibrations and processes; spectral density functions; modal analysis using graphic CRT

display; damping and stiffness techniques for vibration control; sensor techniques for machinery diagnostics; transient response concepts and test procedures; field application of modal analysis for large systems; several sessions on case histories in vibration engineering; applied vibration engineering state-of-the-art.

Contact: Dr. Ronald L. Eshleman, Director, The Vibration Institute, 101 West 55th Street, Suite 206, Clarendon Hills, IL 60514 - (312) 654-2254.

VIBRATION DAMPING TECHNOLOGY
Dates: May 19-23, 1986
Place: Reno, Nevada
Dates: July 14-17, 1986
Place: Montreal, Canada
Dates: September 15-19, 1986
Place: Dayton, Ohio
Dates: January, 1987
Place: Clearwater, Florida
Objective: Basics of theory and application of viscoelastic and other damping techniques for vibration control. The courses will concentrate on behavior of damping materials and their effect on response of damped systems, linear and nonlinear, and emphasize learning through small group exercises. Attendance will be strictly limited to ensure individual attention.

Contact: David I. Jones, Damping Technology Information Services, Box 565, Centerville Branch USPO, Dayton, OH 45459-9998 - (513) 434-6893.

JULY

ROTOR DYNAMICS
Dates: July 14-18, 1986
Place: Rindge, New Hampshire
Objective: The role of rotor/bearing technology in the design, development and diagnostics of industrial machinery will be elaborated. The fundamentals of rotor dynamics; fluid-film bearings; and measurement, analytical, and computational techniques will be presented. The computation and measurement of critical speeds vibration response, and stability of rotor/bearing systems will be discussed in detail. Finite elements and transfer matrix modeling will be related to computation on mainframe computers, minicomputers, and microprocessors. Modeling and computation of transient rotor behavior and nonlinear fluid-film bearing behavior will be described. Sessions will be devoted to flexible rotor balancing including turbogenerator rotors, bow behavior, squeeze-film dampers for turbomachinery, advanced concepts in troubleshooting and instrumentation, and case histories involving the power and petrochemical industries.

Contact: Dr. Ronald L. Eshleman, Director, The Vibration Institute, 101 West 55th Street, Suite 206, Clarendon Hills, IL 60514 - (312) 654-2254.

AUGUST

VIBRATIONS OF RECIPROCATING MACHINERY
Dates: August 19-22, 1986
Place: New Orleans, Louisiana
Objective: This course on vibrations of reciprocating machinery includes piping and foundations. Equipment that will be addressed includes reciprocating compressors and pumps as well as engines of all types. Engineering problems will be discussed from the point of view of computation and measurement. Basic pulsation theory --including pulsations in reciprocating compressors and piping systems -- will be described. Acoustic resonance phenomena and digital acoustic simulation in piping will be reviewed. Calculations of piping vibration and stress will be illustrated with examples and case histories. Torsional vibrations of systems containing engines and pumps, compressors, and generators, including gearboxes and fluid drives, will be covered. Factors that should be considered during the design and analysis of foundations for engines and compressors will be discussed. Practical aspects of the vibrations of reciprocating machinery will be emphasized. Case histories and examples will be presented to illustrate techniques.

Contact: Dr. Ronald L. Eshleman, Director, The Vibration Institute, 101 West 55th Street, Suite 206, Clarendon Hills, IL 60514 - (312) 654-2254.

SEPTEMBER

MODAL TESTING OF MACHINES AND STRUCTURES
Dates: September 8-11, 1986
Place: Chicago, Illinois
Objective: Vibration testing and analysis associated with machines and structures will be discussed in detail. Practical examples will be given to illustrate important concepts. Theory

and test philosophy of modal techniques, methods for mobility measurements, methods for analyzing mobility data, mathematical modeling from mobility data, and applications of modal test results will be presented.

Contact: Dr. Ronald L. Eshleman, Director, The Vibration Institute, 101 West 55th Street, Suite 206, Clarendon Hills, IL 60514 - (312) 654-2254.

NEWS BRIEFS: news on current and Future Shock and Vibration activities and events

Call for Papers

VDI VIBRATIONS MEETING 1986
September 29-30, 1986
Wurzburg, West Germany

The VDI (Society of German Engineers) Vibrations Meeting takes place every two years at different locations. They generate a great deal of interest to anyone involved in either theoretical or applied vibrations. The topic of the next VDI Vibrations Meeting is "Vibrations of Coupled Systems," and will be held September 29-30, 1986 in Wurzburg, West Germany.

Call for Papers

14TH SPACE SIMULATION CONFERENCE
November 3-6, 1986
Sheraton Inner Harbor Hotel
Baltimore, Maryland

The 14th Space Simulation Conference will be hosted by the Institute of Environmental Sciences (IES) and supported by the American Institute of Aeronautics and Astronautics (AIAA), American Society for Testing and Materials (ASTM), and the National Aeronautics and Space Administration (NASA) through mutual interests in technical activities in the subject area.

The theme of the conference is "Testing for a Permanent Presence in Space." The purpose of the conference is to provide a forum for the review and exchange of information and ideas on current space simulation technology and closely related disciplines as well as projections for testing requirements and technology development.

Papers are being solicited in the following subject areas:

Space simulation facilities
Spacecraft testing
Thermal protection
Contamination control
Vacuum/cryogenics
Remote sensing
Large space structures
Materials test
Long term space test/reliability
Heat pipes
Thermal control
New facilities -- monitor and control
Automation
Data handling
Acoustic test
Spacecraft repair/preparation by test

Papers dealing with subjects other than those listed above will be considered for the conference based on their relatedness to these subject areas. Papers summarizing the results of Shuttle Flights and related activity would be of great interest.

Papers for presentation will be selected on the basis of abstracts of approximately 500 words. The abstract should include the description and principal results of the investigation as well as status and extent of the work.

To assure proper consideration of a paper, three copies of the abstract must be submitted before March 5, 1986 to the Technical Program Chairman:

A.R. Lunde MS 86-01
The Boeing Company
P.O. Box 3999
Seattle, WA 98124

An accompanying cover letter should provide the complete paper title, the author's name and affiliation, address and phone number. All papers must be unclassified and not previously published.

Individuals will be notified of the Program Committee's decision by April 16, 1986. The photo ready manuscripts of accepted papers will be required no later than August 15, 1986 in order to be included in the publication of the conference proceedings.

For further information contact: Institute of Environmental Sciences, 940 East Northwest Highway, Mt. Prospect, IL 60056 - (312) 255-1561.

32ND ANNUAL TECHNICAL MEETING OF THE INSTITUTE OF ENVIRONMENTAL SCIENCES
May 5-9, 1986
Dallas/Ft. Worth Airport, TX

Brigadier Sam T. Webber, Director of Electrical and Mechanical Engineering Management Services, Logistic Executive (Army), Great Britain, will be the speaker at the 32nd Annual Technical Meeting Awards banquet. Brigadier Webber has served as Deputy Commander Maintenance in HQ British Army of the Rhine.

The ATM86 Management Committee is preparing the technical program and has all the technical division directors involved in scheduling of the technical sessions. In addition, there are several tutorials being planned. There is to be a one day program co-sponsored by IES and AAAR (American Association of Aerosol Research).

The exposition hall will be sold out prior to the meeting.

The theme of the ATM86 is "Environmental Technology -- Coming of Age." The ATM86 will be held at the Amfac Hotel, Dallas/Ft. Worth Airport, May 5-9, 1986.

Technical Committees and Recommended Practice Working Groups will be scheduled on Monday, May 5 and Friday, May 9, avoiding conflict with any tutorials or technical sessions being held on those days.

For further information contact: Institute of Environmental Sciences, 940 East Northwest Highway, Mt. Prospect, IL 60056 - (312) 255-1561.

REVIEWS OF MEETINGS

56th SHOCK AND VIBRATION SYMPOSIUM
22-24 October, 1985
Monterey Holiday Inn
Monterey, California

The 56th Shock and Vibration Symposium, sponsored by the Shock and Vibration Information Center (SVIC), was held in Monterey in October. It was hosted by the U.S. Naval Postgraduate School on behalf of the U.S. Navy. The formal technical program consisted of more than 60 papers (see Vol. 17, No. 8 of the **Digest** for the complete program; paper summaries are available from the SVIC; papers will be published in the **Shock and Vibration Bulletin**). Technical plenary sessions were conducted during the Symposium. Plenary A was given on pyrotechnic shock by Mr. Chuck Moening and Dr. Sheldon Rubin of Aerospace Corporation. Plenary B was a state-of-the-art assessment of structural dynamic response analysis techniques given by Dr. David J. Ewins of Imperial College. A large and interesting session on short discussion topics covering many areas of mechanical vibration and shock was held. A comprehensive symposium on pyrotechnic shock was conducted -- beginning with the plenary session and continuing with a number of interesting and successful workshops. Dr. J. Gordan Showalter, Acting Director of SVIC, the members of the SVIC staff, and the program committee are to be congratulated for the assembly of an outstanding program on shock and vibration technology. Among the 375 participants were representatives of the federal government, industry, academic institutions, and foreign nationals. The combination of formal and informal technical programs effected a meaningful transfer of shock and vibration technology.

The Opening Session

Dr. Young S. Shin of the Naval Postgraduate School, chairman of the opening session, introduced Dr. Paul Marto, chairman of the Department of Mechanical Engineering at the Naval Postgraduate School, who gave the welcome address. Professor Marto noted that the postgraduate school has been serving the U.S. Navy for 75 years -- starting with 10 students and growing to 1600 students today.

The four papers given in the opening session were reports on research activities in the Army, Navy, Air Force, and NASA. Dr. Benjamin Whang of the David W. Taylor Naval Ship R&D Center gave the first invited paper on the solid mechanics program at the Office of Naval Research (ONR). Dr. Whang noted that the function of the ONR program was to support fundamental research to promote the understanding of the behavior of solid materials and structures. He reviewed the ONR Solid Mechanics Program which included fundamentals of solid mechanics, failure mechanics, fluid-structure interaction, and structural mechanics. A critical concern at this time is the interdisciplinary relationship between materials, structures, and fluids. Surface stress and velocity must be predictable. He cited needs in the areas of the separation of turbulent noise and acoustic signals, unique sound and vibration absorbers and isolators, and acoustically active structures. Some of the issues concerning this group were stated. Can local and global response be solved simultaneously? Can interfacial stresses and velocity due to solid-fluid interaction be used to resolve the source? Can new materials such as composites and polymers be used practically? He concluded that much solid mechanics basic research is in progress and that ample opportunities exist for the shock and vibration community to define new and exciting directions for fundamental research.

The second address was given on behalf of the U.S. Army by Mr. Richard Shea of the U.S. Army Material Technology Laboratory at Watertown. His topic was "Army Research in Shock Mechanics." Mr. Shea provided an overview of the Laboratory's programs on advanced mechanics of materials including research on life prediction/reliability mechanics, composites, and shock impact mechanics. He showed computer output of sample impact phenomena occurring at 5000 ft./sec. Some examples involving penetration mechanics with missiles and explosives were shown. He reviewed the computational procedures and techniques involved in computer simulations of projectiles impacting materials. Finally, the concepts of explosive hardening were reviewed.

The third address was given by Dr. Anthony K. Amos of Bolling Air Force Base on behalf of the Air Force basic research program in dynamics

and control of large space structures. Dr. Amos reviewed the Air Force basic research program including the areas of structural-control dynamics interaction, structural-fluid dynamics interaction, mission performance control, and shock and vibration environments. Examples of problems in these areas include orbital dynamics and pointing accuracy. Structural modeling techniques including feedback control mechanisms by the space state formulation were described. The problems of reduction of model size and control stability were reviewed. The sensitivity of the model to initial parameter characterization was addressed. Finally, the future directions of synthesis and simulation methodology were reviewed.

The fourth and final research program review was given by Dr. Larry Pinson of NASA Langley Research Center on behalf of NASA. Dr. Pinson reviewed structural dynamics research concerned with analysis and test methods, vibration control, and system identification. All this work is concerned with ground tests, orbital tests and focused technology. He discussed approaches for qualification of mathematical models, gravity effects, the development of models through testing, and the control of flexible structures. The research program content specifically contains beam dynamics and controls including active modal damping, 3D dynamics and controls, and multibody dynamics technology. He cited their guest investigator program which supports people who have novel means of attacking control, structural dynamics, and modeling problems. In the area of structural dynamics research, system identification, models, and joints were discussed. Dr. Pinson cited a solar array which had a natural frequency of .04 Hz! However, he noted that in these problems one always ends up with iterations between models and tests to learn what is model sensitive. Research on joint dominated structures has been ongoing -- including the nonlinear stiffness and hysteretic damping properties. In summary Dr. Pinson commented on the progress on NASA control of flexible structure program, system identification procedures, scale model applications, joint modeling, and behavior and prediction of large structural motions.

The Plenary Sessions

Dr. Sheldon Rubin provided a history on the motivation and organization of the pyrotechnic workshop through an earlier IES meeting. He described some early experiences with shock induced relay problems. He noted that people should be aware of what is included in MIL-STD-810D. He introduced Mr. Chuck Moening who provided a historical overview of the pyrotechnic shock area. Mr. Moening has been manager of the environmental criteria and test section at the Aerospace Corporation since 1958. He noted that the pyrotechnic device gets only one chance on an aerospace vehicle. He talked about "famous last words" in the pyrotechnic shock area: 1959 -- "The duration of the shock environment is too short to cause failure -- a three minute vibration test is more severe;" 1960-1970 -- "our electrical equipment will be reduced to scrap if exposed to several thousand g's;" 1966 -- "pyrotechnic shock is caused by explosive charge -- reduce the charge to reduce the shock;" 1964-1975 -- "pyrotechnic shock can be attenuated by use of dissimilar materials in structural interfacial joints;" 1960-1980 --"the predicted shock levels are much too high." Mr. Moening went on to provide an interesting historical perspective of how the area of pyrotechnic shock grew and evolved from art to science over the past 25 years. He provided some records on successes and failures which allow a self examination of the success of the shock and vibration community in this area.

The second plenary session was given by Dr. David J. Ewins of Imperial College on a state-of-the-art assessment of structural dynamic response analysis. The study was motivated by a similar series of modal tests sponsored by the U.S. Navy and done by independent laboratories. In that case physical models were distributed to laboratories for testing of their modal properties. In the present series of "tests" drawings were sent to the participants for computations. The structure to be tested, which had some challenging properties including pipe threads, was described along with the specific properties and responses to be calculated. The inertial properties, modes of vibration (17 points), frequency response, and transient response were obtained. Originally twenty-seven (27) organizations were invited with twenty-four (24) in agreement to participate. Thirteen (13) submissions have been received to date on the project. Some of the results, reviewed by Dr. Ewins, showed many agreeable conclusions; however, there were some differences. The results showed good low frequency agreement with more dispersion as the frequency goes up. Mr. Richard Windell of the British Navy who was a sponsor and a participant gave a very interesting report on the thoughts and results of a participant. Mr. Windell is to be commended for his forthright, honest appraisal of the problem. He reviewed the difficult modeling problems -- including the stiffness and damping of the supports and the main structure. He showed his calculated results compared to experiments. Similar to other

calculated results low frequency responses were in good agreement with tests but as frequencies increased the agreement between calculation and test became less pronounced. Transient response calculations showed good agreement with tests for a soft hammer blow.

The Technical Sessions

The pyrotechnic shock workshop featured sessions in data interpretation, design and test requirements, instrumentation, data acquisition and data bank, and simulation and testing. Pyroshock Workshop I on data interpretation, design and test requirements was chaired by Dan Van Ert of Aerospace Corporation and Hank Luhrs of TRW. The invited speakers included Ken Kalbfleisch -- "Review of Pyro Shock Generating Devices and Source Levels," Richard Chalmers --"How Best to Measure Pyrotechnic Shock?", Chuck Moening --"A Frequency and Path Length Dependent Pyro-Shock Prediction Approach," Hank Luhrs --"Designing Electronics for Pyro-Shock," and Fred Spann -- "Pyro-Shock Attenuation Techniques." Session II on instrumentation, data acquisition and data bank was chaired by Glen Wasz of TRW. Invited speakers included Bill Henricks on "Database Management Systems," Jon Wilson on "State of the Art Accelerometer Characteristics," Arnold Galef on "Zero-Shifted Accelerometer Outputs," and Paul Strauss on "Effects of Shock Data Filtering." The final pyroshock workshop on simulation and testing was chaired by Dan Powers. The invited speakers were Robert E. Morse -- Comparison of Response from Different Resonant Plate Simulation Techniques," Niel Davie -- "Controlled Response of Resonating Fixtures," Fred Safford --"Multi-Axis Transmission Shock Simulation Using Mechanical Pulse Generators," and Glen Wadleigh -- Gas Energized Impact Shock Tester." Dan Powers gave a closing summary of testing techniques. These workshops were a tremendous success -- with meaningful discussion among new and old researchers.

A successful session on pyrotechnic shock and shipboard shock preceded the workshop. This session featured papers on linear separation, zero shift piezoelectric accelerometers, numerical simulation and computation of excitation forces using structural response data. A session on blast and ground shock provided interesting papers on the dynamic response of armor plate, evaluation of shock response in combat vehicles, blast shelters, a "numerical gauge" for structural assessment, and computer implementation of a muzzle blast prediction technique. A session on shock testing and analysis contained papers on shock reconstruction from the shock spectrum. Shock response spectrum at low frequencies, and an investigation into the effects of using detonating cord to remove a conventional propeller from a waterborne surface ship.

Sessions on modal test and analysis and testing techniques contained papers on multiple tests concept for improved validation of large space structure mathematical models, automating the modal analysis process, parameter identification methods, random variation of modal frequencies, testing of graphite-epoxy laminates and digital control systems. In the machinery dynamics area papers were presented on the prediction of natural frequencies of flexible disk systems, parameter identification of a non-linear dynamic system and force magnitude and angular velocity reduction of a spring retained, flexibly supported, four bar mechanical linkage.

An interesting session on isolation and damping featured papers on analytically determined response of elastically isolated equipment to random vibration base motion, the application of impedance models to the design of machinery foundations, temperature shift considerations for damping materials and nonsynchronous motion of squeeze film damper systems.

The session on structural dynamics contained papers on the buckling of ring stiffened cylindrical shells under dynamic loads, the use of simplified models in the supercomputer era, and work on nonlinear resonances. Papers on fatigue acoustics and fluid flow featured metal fatigue using Miner's rule, vibration specifications, and excitations due to fluid flow.

Conclusion

The Fifty-sixth Shock and Vibration Symposium was both technically informative and interesting yielding a large number of excellent papers. Again the plenary sessions with their overviews and philosophical insights added incomprehensible value to the meeting for new and experienced engineers. The workshop on pyroshock was a very successful addition to the program yielding motivation, training, and experience for those who participated. The Shock and Vibration Symposium continues to be the major annual event in this field and the SVIC can be congratulated for their continued maintenance of the quality of the technical presentations and the

organization of interesting update lectures, overviews, and philosophical discussions so necessary for a complete meeting. Papers presented at the Symposium will be reviewed for quality of technical content and published in the **56th Shock and Vibration Bulletin** published by the SVIC.

R.L.E.

ABSTRACTS FROM THE CURRENT LITERATURE

ABSTRACT CONTENTS

AVAILABILITY OF PUBLICATIONS ABSTRACTED

None of the publications are available at SVIC or at the Vibration Institute, except those generated by either organization.

Periodical articles, society papers, and papers presented at conferences may be obtained at the Engineering Societies Library, 345 East 47th Street, New York, NY 10017; or Library of Congress, Washington, D.C., when not available in local or company libraries.

Government reports may be purchased from National Technical Information Service, Springfield, VA 22161. They are identified at the end of bibliographic citation by an NTIS order number with prefixes such as AD, N, NTIS, PB, DE, NUREG, DOE, and ERATL.

Ph.D. dissertations are identified by a DA order number and are available from University Microfilms International, Dissertation Copies, P.O. Box 1764, Ann Arbor, MI 48108.

U.S. patents and patent applications may be ordered by patent or patent application number from Commissioner of Patents, Washington, D.C. 20231.

Chinese publications, identified by a CSTA order number, are available in Chinese or English translation from International Information Service, Ltd., P.O. Box 24683, ABD Post Office, Hong Kong.

Institution of Mechanical Engineers publications are available in U.S.: SAE Customer Service, Dept. 676, 400 Commonwealth Drive, Warrendale, PA 15096, by quoting the SAE-MEP number.

When ordering, the pertinent order number should always be included, not the **DIGEST** abstract number.

A List of Periodicals Scanned is published in issues, 1, 6, and 12.

MECHANICAL SYSTEMS

ROTATING MACHINES

86-1
Control of Stability and the Synchronous Vibration of a Flexible Rotor Supported on Oil-Film Bearings
M.N. Sahinkaya, C.R. Burrows
Univ. of Strathclyde, Glasgow, Scotland
J. Dynam. Syst., Meas. Control, Trans. ASME, 107 (2), pp 139-144 (June 1985), 7 figs, 1 table, 17 refs

KEY WORDS: Flexible rotors, Fluid film bearings, Whirling, Synchronous vibration

The relationship between eigenvalue loci for the rotor-bearing systems and the onset of instability due to oil-whirl, is utilized to derive an algorithm to control the onset of instability. Implementation of the algorithm is discussed. It is shown how this can be combined with an open-loop adaptive control strategy to ensure the stability of a flexible rotor and also minimize the synchronous vibration throughout the operational speed range.

86-2
Rotor Axial Vibration Caused by Gear Coupling
S. Yanabe, M. Fuwano, K. Kikuchi
Technological Univ. of Nagaoka, Nagaoka, Niigata, Japan
Bull. JSME, 28 (241), pp 1497-1504 (July 1985), 15 figs, 7 refs

KEY WORDS: Rotors, Axial vibration, Gear couplings, Alignment

Axial vibration of a horizontal rotor driven through a single craw type gear coupling under no load operating condition is studied. The effects of coupling misalignment on the vibration are experimentally investigated. To illustrate the mechanism of the axial vibration three models are proposed on the basis of experimental results.

86-3
Torsional Stress Wave — Passing Through the Shaft with Rigidly Fixed Part of Lateral Area
R. Brepta, J. Cerv
Faculty of Nuclear and Physical Engrg., Prague, Czechoslovakia
Strojnicky Casopis, 36 (1), pp 21-33 (1985), 12 figs, 5 refs (In Czech)

KEY WORDS: Shafts, Torsional excitation

Results of computation of stress and displacement - distribution in a shaft under torsional impact load are presented. The finite element method was used for the solution. The aim of these calculations was to find the power of the used method to identify the stress-singularity in the case of a small number of elements.

86-4
Solving U-Joint Vibration Problems
P.J. Mazziotti
Parrish Power Products, Inc., Toledo, OH
Power Trans. Des., 27 (7), pp 85-88 (July 1985), 6 figs

KEY WORDS: Cardan shafts, Vibration control

Flexible couplings are used to join driving and driven shafts to transmit power. Unlike conventional flexible couplings that accommodate 2 to 3 deg of misalignment, U-joints routinely accommodate 8 deg of misalignment - up to 30 deg for short durations. One of the most popular types, the Cardan, is described.

86-5
Load-Induced Rotordynamic Instabilities in Turbomachinery
Kyung Bin Yim
Ph.D. Thesis, Texas A&M Univ., 219 pp (1984) DA8504726

KEY WORDS: Rotors, Turbomachinery, Flexibility coefficients

By employing the extended Hamilton principle, both equations of motion and associated boundary conditions are derived for three different models subjected to non-conservative torques: the cantilevered rotor, the uniform shaft on rigid short bearings, and the uniform shaft on rigid long bearings. The characteristic frequency equations for these models are formulated by introducing a complex deflection and nondimensional parameters.

86-6

Modern Aids in the Design and Development of Turbines (Moderne Hilfsmittel fur die Konstruktion und Entwicklung von Turbogetrieben)

J. Theissen, H. Ostendarp

Konstruktion, 37 (5), pp 192-200 (May 1985), 22 figs, 10 refs (In German)

KEY WORDS: Turbines, Design techniques

The authors describe basic calculations for the design of individual components, the analysis of static and dynamic effects and the evaluation of performance of turbines.

86-7

Power Plant Noise and Vibration. Fans and Blowers - A Selected Bibliography

N.A. Nilsson, G. Westerberg

Stiftelsen foer Vaermeteknisk Forskning, Stockholm, Sweden

Rept. No. SVF-145, 127 pp (Oct 1983), DE-85750205/GAR

KEY WORDS: Fans, Blowers, Power plants, Noise generation, Bibliographies

This bibliography will serve as a first stage in a study on noise and vibration from fans and blowers with special reference to power plant applications. The aim of this work has been to provide a survey of the field.

86-8

An Experimental Investigation of the Generation and Consequences of Acoustic Waves in an Axial Flow Compressor: Large Axial Spacings Between Blade Rows

R. Parker, S.A.T. Stoneman

Univ. College Swansea, Singleton Park, Swansea SA2 8PP, Wales

J. Sound Vib., 99 (2), pp 169-182 (Mar 22, 1985), 10 figs, 1 table, 7 refs

KEY WORDS: Compressors, Sound generation, Vortex shedding

The excitation of acoustic modes in the annulus of a single stage, low speed, axial flow compressor was investigated experimentally. The modes were excited by vortex shedding from the inlet guide vanes and each mode was found to be associated with a number of rotor blade vibration excitation frequencies.

86-9

Vacuum Pump Noise Control

D.A. Dmytrow

E.B. Eddy Forest Products Ltd., Quebec, Canada J8X 3Y7

Tappi J., 68 (7), pp 108-109 (July 1985), 3 figs

KEY WORDS: Pumps, Noise reduction

A vacuum pump, regardless of brand or size, is a source of loud noise. Noise sources and control are discussed.

86-10

Power Plant Noise and Vibration. Pumps - a Selected Bibliography

N.A. Nilsson, G. Westerberg

Stiftelsen foer Vaermeteknisk Forskning, Stockholm, Sweden

Rept. No. SVF-144, 114 pp (Oct 1983), DE-85750204/GAR (In Swedish)

KEY WORDS: Pumps, Power plants, Bibliographies

This bibliography will serve as a first stage in a study of noise and vibration from pumps with special reference to power plant applications. This work provides a survey of the field.

86-11

Noise of Counter-Rotation Propellers

D.B. Hanson

Hamilton Standard, United Technologies Corp., Windsor Locks, CT

J. Aircraft, 22 (7), pp 609-617 (July 1985), 11 figs, 1 table, 15 refs

KEY WORDS: Propellers, Noise generation

Theory is presented for noise generation of counter-rotation propellers with special emphasis given to the effects of acoustic and aerodynamic interference between the two rotors. New radiation formulas are given for noise caused by unsteady loading. Spinning mode characteristics similar to those of turbofans are explicitly displayed so that reinforcements and cancellations between acoustic fields of two rotors or between acoustic modes of one rotor can be studied.

86-12
Finite Difference Analysis of Torsional Vibrations of Pretwisted, Rotating, Cantilever Beams with Effects of Warping
K.B. Subrahmanyam, K.R.V. Kaza
NASA Lewis Res. Ctr., Cleveland, OH 44135
J. Sound Vib., 99 (2), pp 213-224 (Mar 22, 1985), 6 tables, 16 refs

KEY WORDS: Rotating structures, Cantilever beams, Torsional vibrations, Warping

Theoretical natural frequencies of the first three modes of torsional vibration of pretwisted, rotating cantilever beams are determined for various thickness and aspect ratios. Conclusions concerning individual and collective effects of warping, pretwist, tension-torsion coupling and tennis racket effect (twist-rotational coupling) terms on the natural frequencies are drawn from numerical results obtained by using a finite difference procedure with first order central differences.

ELECTROMECHANICAL SYSTEMS

86-13
Hospital Air Conditioning Chiller Noise and Vibration Reduction
C.D. Powell, C.P. Dietz, M.J. Popson
O'Donnell & Assoc., Inc., Pittsburgh, PA
Experimental Mechanics, Proc. 1985 SEM Spring Conf., June 9-14, 1985, Las Vegas, NV, pp 869-871, 10 figs

KEY WORDS: Air conditioning equipment, Hospitals, Vibration control, Noise reduction

Solution to a vibration problem in a hospital was achieved through the use of a seismic mass, double isolated with regulated air springs, producing a vibration proof foundation.

STRUCTURAL SYSTEMS

BRIDGES

86-14
Effects of Surface Irregularities Upon the Dynamic Response of Bridges Under Suspended Moving Loads
J. Palamas, O. Coussy, Y. Bamberger
Service de Mecanique, Laboratoire Central des Ponts et Chaussees, Paris, Cedex 15, France
J. Sound Vib., 99 (2), pp 235-245 (Mar 22, 1985), 11 figs, 1 table, 9 refs

KEY WORDS: Bridges, Moving loads, Geometric imperfection effects, Surface roughness

The effects of surface irregularities upon the dynamic response of bridges under suspended moving loads is analyzed by means of a theoretical study. The paper deals with geometrical imperfections of two types, global and local. The vehicle dynamics model is a simple degree of freedom oscillator and the Rayleigh-Ritz method of analysis is used.

BUILDINGS

86-15
Dynamic Behaviour of Clasp-Type Buildings
A.A. Dumanoglu, R.T. Severn
Univ. of Bristol, UK
Earthquake Engrg. Struc. Dynam., 13 (4), pp 481-505 (July/Aug 1985), 22 refs, 6 tables, 17 refs

KEY WORDS: Multistory buildings, Seismic design

The dynamic behavior of pin-jointed, steel-framed buildings which derive stiffness from bracing and cladding is studied and their response to earthquake loading is presented.

86-16
Dynamic Response of Bilinear Asymmetric Structures
P.K. Syamal, O.A. Pekau
Concordia Univ., Montreal, Quebec, Canada
Earthquake Engrg. Struc. Dynam., 13 (4), pp 527-541 (July/Aug 1985), 13 figs, 21 refs

KEY WORDS: Buildings, Periodic excitation, Seismic excitation, Kryloff-Bogoliuboff

The inelastic behavior of eccentric single-story building structures subjected to sinusoidal ground excitation is examined. The Kryloff-Bogliuboff method is employed to provide approximate solutions in the amplitude-frequency domain. Structural resisting elements are assumed to

exhibit bilinear hysteretic behavior and coupled response is investigated in terms of both system response as well as individual element ductility requirements. In addition to demonstrating the well-known softening property inherent in yielding systems, the importance of the principal parameters governing coupled response evaluated in a consistent parametric fashion.

86-17
Lessons from Structural Testing Under Impulsive Loads
T. Krauthammer
Univ. of Minnesota, Minneapolis, MN 55455
Experimental Mechanics, Proc. of the 1985 SEM Spring Conf., June 9-14, 1985, Las Vegas, NV, pp 494-499, 2 figs, 27 refs

KEY WORDS: Shock tests, Buildings

Structural testing under impulsive loads, such as those generated by high explosives, is an acceptable procedure for the assessment of structural resistance to such environments. Issues are presented and discussed to demonstrate the effectiveness of such methods and possible difficulties that could lead to undesirable performance.

TOWERS

86-18
Stochastic Time-History Analysis of Structural Vibration with Uncertain Damping
S. Nakagiri, T. Hisada, K. Toshimitsu
Univ. of Tokyo, Tokyo, Japan
Probabilistic Structural Analysis. The 1984 Pressure Vessel and Piping Conf. and Exhibition, San Antonio, TX, June 17-21, 1984. ASME-PVP-Vol. 93, pp 109-120, 7 figs, 1 table, 9 refs

KEY WORDS: Stochastic processes, Finite element technique, Seismic design, Damping effects, Perturbation theory

The stochastic finite element method is extended to the problem of dynamic response of multiply supported structures with uncertain damping. The methodology is formulated based on the second order perturbation technique applied to the governing equation of motion with uncertain damping. The governing equation and unknowns like normal-coordinates are expanded in terms of the random variables representing the uncertainty. Numerical examples of a tower-structure and a piping demonstrate the validity and efficiency of the formulation.

FOUNDATIONS

86-19
Flexural Responses of Grouped Piles Under Dynamic Loading
T. Nogami
Univ. of Houston, Houston, TX
Earthquake Engrg. Struc. Dynam., 13 (3), pp 321-336 (May/June 1985), 17 figs, 11 refs

KEY WORDS: Pile structures, Flexural vibration, Soil-structure interaction

A simple approach to analyze the flexural vibration of grouped piles is developed. In this approach a pile group is replaced by a single pile for the evaluation of the pile-head flexibility matrix. Parametric studies are conducted for various conditions of grouped piles. The charts presented enable quick estimations of dynamic group effects to be made in a manner similar to what widely used for the evaluation of static group effects.

86-20
New Approach to One-Dimensional Pile-Driving Analysis
H.A. Simons, M.F. Randolph
Cambridge Univ., UK
Rept. No. CUED/D-SOILS/TR-159, 11 pp (1984), PB85-163335/GAR

KEY WORDS: Pile driving, Soils, Stiffness coefficients, Damping coefficients

A new approach to modeling the soil behavior in a one dimensional pile-driving analysis is formulated. The approach uses the theory of dynamic elasticity to determine the soil stiffness and damping coefficients and a yielding mechanism is employed which is consistent with the physical process involved. The approach is found to offer a solution which is potentially as rigorous as that of the finite element method, but significantly simpler to use.

86-21
Transfer Matrix Approach for Nonlinear Pile Group Response Analysis
T. Nogami, S.K. Paulson
Univ. of Houston, Houston, TX
Intl. J. Numer. Anal. Methods Geomech., 9 (4), pp 299-316 (July/Aug 1985), 15 figs, 22 refs

KEY WORDS: Pile structures, Transfer matrix method, Nonlinear response

A transfer matrix method is applied for the analysis of nonlinear pile group responses. The expression for the transfer matrix is obtained by idealizing the nonlinear pile group as a group of piles attached to a piecewise linear 'Winkler model for a pile group.' This Winkler idealization is essential to apply a transfer matrix method for the pile group response analysis.

86-22
Analysis of Dynamic Behavior of Piles
Y.K. Chow
National Univ. of Singapore, Singapore,
Intl. J. Numer. Anal. Methods Geomech., 9 (4), pp 383-390 (July/Aug 1985), 6 figs, 1 table, 13 refs

KEY WORDS: Piles, Finite element technique, Soil-structure interaction

The finite element approach is used to derive element matrices suitable for the analysis of the dynamic behavior of piles. Using this method piles with arbitrary cross-section and soil with nonhomogeneous properties can be analyzed.

86-23
Response Spectra for Torsion, Rocking and Rigid Foundations
A. Rutenberg, A.C. Heidebrecht
Technion-Israel Inst. Technology, Haifa, Israel
Earthquake Engrg. Struc. Dynam., 13 (4), pp 543-557 (July/Aug 1985), 7 figs, 22 refs

KEY WORDS: Rigid foundations, Seismic excitation, Torsional response, Rocking, Response spectra

Simple procedures are proposed for computing response spectra for torsional and rocking input ground motions assuming horizontally travelling waves of constant shape. It is shown that harmonic relationships exist between the rotational spectra and the corresponding translational spectra, and that SV rather than PSV is the correct basis for deriving the angular displacement, velocity and acceleration response spectra. An approximation enabling the use of the standard tripartite logarithmic response spectra is discussed. Simple expressions for accidental eccentricity and rocking input effects are presented.

86-24
Vibrational Modes of the Pedestal Support System for the SLC Arc Magnets
W.T. Weng, A.W. Chao
Stanford Linear Accelerator Ctr., CA
Rept. No. SLAC/AP-35, 9 pp (Oct 1984), DE-85006246/GAR

KEY WORDS: Supports, Magnets, Mode shapes

The magnet support system for the SLC Arcs is a long series of pedestals with each pedestal supporting the ends of two adjacent magnets. Random magnet vibrations in the Arc with large amplitudes are potentially harmful for the SLC operation. In order to assess the vibrational behavior of the Arc magnet system, the sources and characteristics of the ground disturbances, the coupled vibrational modes of the composite pedestal magnet system and, the response of the system to ground disturbance must be understood.

86-25
A Note on the Added Mass and Wave Damping of a Column with Circular Footing
G.P. Miao, Y.Z. Liu, J.S. Chung
Shanghai Jiao Tong Univ., Shanghai, China
J. Energy Resources Tech., Trans. ASME, 107 (2), pp 235-237 (June 1985), 2 figs, 1 table, 15 refs

KEY WORDS: Footings, Columns, Off-shore structures, Added mass effects, Damping effect

A column with footing of offshore floating structures is one of the common structural members for many semisubmersible ocean platforms. A vertical column with circular footing produces three-dimensional flows over the footing itself and at the joint line of the footing with the column. A variety of elaborate methods exist for solution of such a three-dimensional hydrodynamic problem. A method based on the eigen-

function expansion and matching of flow fields is developed. A comparison of theoretical results using this method with the limited experimental data is presented.

UNDERGROUND STRUCTURES

86-26
Dynamic Characterization of Geological Materials from Shock Hugoniot Characteristics
A.D. Gupta
U.S. Army Ballistic Res. Lab., Aberdeen Proving Ground, MD 21005
Experimental Mechanics, Proc. 1985 SEM Spring Conf., June 9-14, 1985, Las Vegas, NV, pp 199-204, 2 figs, 10 refs

KEY WORDS: Soils, Blast response, Hugoniot equation

Under the assumption of unidimensional shock propagation and conservation laws of mass, momentum and energy, characterization of constitutive behavior of three geological materials has been obtained from shock compression behavior of such materials and their Hugoniot characteristics.

CONSTRUCTION EQUIPMENT

86-27
Vibrating Subsoilers: A Way to Reduce Power and Draft Forces in Soil Preparation
F.P. Lepore, V. Steffen
Experimental Mechanics, Proc. 1985 SEM Spring Conf., June 9-14, 1985, Las Vegas, NV, pp 775-778, 8 figs, 6 refs

KEY WORDS: Vibratory tools, Agricultural machinery, Compaction equipment

The possibilities of draft forces and total power reductions are analyzed when a subsoiler is submitted to a vibratory motion superimposed to its forward motion, by verifications conducted in a soil bin and by field tests using reduced scale models. Using diagrams of force the dynamic behavior of the soil-tool-system is identified.

POWER PLANTS

86-28
Probabilistic Seismic Resistance of a Mark III Steel Containment
L. Greimann, F. Fanous
Iowa State Univ., Ames, IA
Probabilistic Structural Analysis. The 1984 Pressure Vessel and Piping Conf. and Exhibition, San Antonio, TX, June 17-21, 1984. ASME-PVP-Vol. 93, pp 27-39, 4 figs, 1 table, 21 refs

KEY WORDS: Nuclear power plants, Nuclear reactor containment, Steel, Seismic response

Concern for the safety of nuclear power plants has motivated efforts to determine the statistical characteristics of the seismic resistance of steel containments. This paper represents a portion of a project whose objective is to assess the uncertainty of containment strength subjected to earthquakes and other types of loading. The seismic response is predicted by a random vibration technique and calibrated to a design response spectrum. BOSOR4 is first used to predict linear vibration modes. Modal analysis methods are utilized, with the random vibration technique, to obtain a statistical description of the random process stress resultants for a unit g peak ground acceleration.

86-29
Sensitivity of Seismic Risk Models
M.K. Ravindra, H. Banon, R.H. Sues
Structural Mechanics Associates, Inc., Newport Beach, CA
Probabilistic Structural Analysis. The 1984 Pressure Vessel and Piping Conf. and Exhibition, San Antonio, TX, June 17-21, 1984. ASME-PVP-Vol. 93, pp 1-26, 7 figs, 12 tables, 15 refs

KEY WORDS: Nuclear power plants, Seismic response

Sensitivity of seismically-induced severe core damage frequency is investigated using the Zion, Indian Point Unit 2 and Limerick probabilistic safety studies as base cases. Included in the study are the effects of hazard curve truncation at upper bound accelerations, the effect of fragility curve cutoff, the risk contribution of component capacity uncertainty and randomness, the influence of probability distribution assumptions, the impact of correlation between compo-

nent failures and the significance of gross design and construction errors.

OFF-SHORE STRUCTURES

86-30
Nonlinear Inverse Perturbation in Structural Dynamics Redesign of Risers
M.M. Bernitsas, C.J. Hoff, J.E. Kokarakis
Univ. of Michigan, Ann Arbor, MI 48109
J. Energy Resources Tech., Trans. ASME, 107 (2), pp 256-263 (June 1985), 3 figs, 4 tables, 23 refs

KEY WORDS: Marine risers, Structural modification techniques

Marine risers, and offshore structures in general, may have undesirable natural frequencies and/or mode shapes. Structural redesign is mandatory in such cases. An Inverse Perturbation Redesign (IPR) method which uses only the finite element analysis of the baseline system and was developed in previous work for general structures, is extended in this work to handle systems with geometric stiffness matrices like marine risers.

VEHICLE SYSTEMS

GROUND VEHICLES

86-31
Comparison of Anthropomorphic Dummy and Cadaver Head Impacts
C. Ward, D. Schneider
Biodynamics/Engineering, Inc., Pacific Palisades, CA
Experimental Mechanics, Proc. 1985 SEM Spring Conf., June 9-14, 1985, Las Vegas, NV, pp 347-353, 8 figs

KEY WORDS: Collision research (automotive), Anthropomorphic dummies

Crash dummies must meet certain design criteria, be durable and produce repeatable results. Dummy kinematic and dynamic responses should be comparable to those of the human. These response characteristics are categorized as dynamic biofidelity. Frontal, mandible and lateral impacts to the dummy heads were repeated on human cadaver heads, and the resultant head accelerations compared. The effects of the variations on injury assessment and brain response is discussed.

SHIPS

86-32
Numerical Analysis of the Elastic Shock Response of Submarine Installed Equipment
M.S. Welch
Naval Postgraduate School, Monterey, CA
115 pp (Sept 1984), AD-A152 564/1/GAR

KEY WORDS: Shipboard equipment response, Submarines, Nuclear powered ships

Motivated by a lack of explosive test data on nuclear submarines, the Navy has sought other means to qualify installed equipment in submarine environments. This thesis is a comparative study of ELSHOK (Elastic Shock) -- a new generation numerical shock response code. The limitations and strong points of both methods are examined using illustrative examples.

86-33
Application of Digital Cross-Bispectral Analysis Techniques to Model the Nonlinear Response of a Moored Vessel System in Random Seas
DooWhan Choi, R.W. Miksad, E.J. Powers, F.J. Fischer
Univ. of Texas, Austin, TX
J. Sound Vib., 99 (3), pp 309-326 (Apr 8, 1985), 12 figs, 18 refs

KEY WORDS: Ships, Bispectral Analysis, Random excitation

Digitally implemented cross-bispectral analysis techniques are utilized to model the quadratically nonlinear response of moored vessels subject to random seas. The model, based on a Volterra series representation, consists of a parallel combination of linear and quadratic transfer functions. The key ideas underlying the estimation of the quadratic transfer functions by applying digital cross bispectral analysis to the sea

wave input and moored vessel response data are described.

86-34
Roll Motion of a Ship in Random Beam Waves: Comparison Between Theory and Experiment
J.B. Roberts, N.M.C. Dacunha
Univ. of Sussex, Falmer, Brighton, Sussex, UK
J. Ship Res., 29 (2), pp 112-126 (June 1985), 11 figs, 25 refs

KEY WORDS: Ships, Wave forces, Rolling motion, Random excitation

The results of an experimental study of a ship rolling in random beam waves at zero speed are presented. The experiments were conducted in a large wave tank using a 1:20 scale model of a fisheries protection vessel. By digitally processing the roll response measurements obtained over long periods of time, estimates of the probability distribution of the roll peak amplitudes were obtained and compared with some corresponding theoretical predictions.

86-35
Estimation of Nonlinear Ship Roll Damping from Free-Decay Data
J.B. Roberts
Univ. of Sussex, Falmer, Brighton, Sussex, UK
J. Ship Res., 29 (2), pp 127-138 (June 1985), 11 figs, 5 tables, 9 refs

KEY WORDS: Ships, Rolling motion, Nonlinear damping

A common method of assessing the damping present in ship rolling motion is to perform a free-decay experiment, in which, in the absence of waves, the ship is given an initial roll amplitude and then released. By processing the resulting decaying, oscillatory trace it is possible to estimate quantitatively the degree of damping, even when this is nonlinear. An approach to the estimation of nonlinear damping is proposed which involves the use of a cubic spline interpolation of the peak amplitudes, followed by a parametric identification procedure.

86-36
Forward-Speed Vertical Wave Exciting Forces on Ships
P.D. Sclavounos
Massachusetts Inst. of Tech., Cambridge, MA
J. Ship Res., 29 (2), pp 105-111 (June 1985), 10 figs, 20 refs

KEY WORDS: Ships, Wave forces, Hydrodynamic excitation

Expressions are derived for the heave and pitch exciting force and moment on a ship advancing in waves. They are obtained in the form of an integral over the ship axis of the outer source strength of the reverse-flow radiation problem multiplied by the value of the incident-wave velocity potential. Their performance is tested for two slender spheroids. Comparisons are made with predictions obtained from a three-dimensional numerical solution at zero speed -- the expression common to strip-theory programs which uses the ship hull as the integration surface -- and the direct solution of the diffraction problem.

AIRCRAFT

86-37
Extraction of Helicopter-Radiated Noise by Frequency Domain Processing
R.F. Dwyer
Naval Underwater Systems Ctr., New London, CT 06320
J. Acoust. Soc. Amer., 78 (1), pp 95-99 (July 1985), 4 figs, 7 refs

KEY WORDS: Helicopter noise, Frequency domain method

Real data observations of farfield radiated noise from an approaching UH-1 helicopter revealed that the received time-domain radiated noise contained impulses. The cited literature attributes these observed impulses to blade slap which is caused by, among other mechanisms, blade vortex interactions. This paper is concerned exclusively with extracting these measured impulses by a frequency-domain processing method. The method utilizes a nonlinearity implemented in the frequency domain.

86-38
Analytical and Flight Investigation of the Influence of Rotor and Other High-Order Dynamics on Helicopter Flight-Control System Bandwidth

R.T.N. Chen, W.S. Hindson
NASA Ames Res. Ctr., Moffett Field, CA
Rept. No. A-85153, NASA-TM-86696, 20 pp (Feb 1985), N85-21174/6/GAR

KEY WORDS: Flight vehicle equipment response, Helicopters, Vibration response

The increasing use of highly augmented digital flight-control systems in modern military helicopters prompted an examination of the influence of rotor dynamics and other high-order dynamics on control-system performance. A study was conducted to correlate theoretical predictions of feedback gain limits in the roll axis with experimental test data obtained from a variable-stability research helicopter. Feedback gains, the break frequency of the presampling sensor filter, and the computational frame time of the flight computer were systematically varied.

86-39
Evaluation of Interior Noise Control Treatments for Advanced Turboprop Aircraft
R.A. Prydz, J.D. Revell, F.J. Balena, J.L. Hayward
Lockheed-California Co., Burbank, CA
J. Aircraft, 22 (6), pp 523-529 (June 1985), 18 figs, 14 refs

KEY WORDS: Aircraft noise, Interior noise, Noise reduction, Experimental data

Experimental noise-reduction data is obtained on a 43% scale model of a typical narrow-body aircraft. The acoustic performance of six sidewall add-on noise-reduction treatment designs is evaluated under random and harmonic acoustic excitations and compared with predictions. A previously derived mathematical model for sound transmission into a stiffened cylindrical shell with multilayered treatments is used for the predictions.

86-40
Improved Source Model for Aircraft Interior Noise Studies
J.R. Mahan, C.R. Fuller
Virginia Polytechnic Inst. and State Univ., Blacksburg, VA
Rept. No. NASA-CR-172517, 30 pp (Jan 1985), N85-17668/3/GAR

KEY WORDS: Aircraft, Interior noise, Noise reduction

An existing analytical model for noise transmission into aircraft cabins was utilized to investigate the behavior of an improved propeller source model for use in aircraft interior noise studies. The new source model, a virtually rotating dipole, is shown to adequately match measured fuselage sound pressure distributions, including the correct phase relationships, for published data. The virtually rotating dipole is used to study the sensitivity of synchrophasing effectiveness to the fuselage sound pressure trace velocity distribution. Results of calculations are presented.

86-41
Approach to Interior Noise Control Part I: Damped Trim Panels
C.I. Holmer
Cabot Corp., Indianapolis, IN
J. Aircraft, 22 (7), pp 618-623 (July 1985), 7 figs, 2 tables, 12 refs

KEY WORDS: Aircraft noise, Interior noise, Noise control, Internal damping, Flexural stiffness

The attenuation mechanisms for interior trim panel systems are reviewed, emphasing the significance of structure-borne transmission through the trim attachments. The significant factors for high-frequency performance include number of attachments per unit area, panel critical frequency, and panel damping. The need for sufficient damping below and maximal damping above the trim panel critical frequency is described. Described are two experimental flight demonstrations that emphasize the role of trim panel damping.

86-42
Flight Test Technique for Evaluation of Gust Load Alleviation Analysis Methodology
B. Perry
NASA Langley Res. Ctr., Hampton, VA
Rept. No. NASA-TM-86344, 22 pp (Dec 1984), N85-14833

KEY WORDS: Aircraft wings, Wind-induced excitation, Testing techniques

A technique for gust load alleviation flight testing that will approximate a turbulence-like excitation of the wing has been devised. An artificial excitation is produced by randomly

deflecting inboard control surfaces on the wing, thereby producing incremental loads on the wing. This presentation covers the background and development of the flight test technique and analyses performed to date.

86-43

Winglet Effects on the Flutter of a Twin-Engine Transport-Type Wing

K.G. Bhatia, K.S. Nagaraja, C.L. Ruhlin
Boeing Commercial Airplane Co., Seattle, WA
J. Aircraft, 22 (7), pp 587-594 (July 1985), 10 figs, 10 refs

KEY WORDS: Aircraft wings, Flutter

Flutter characteristics of a cantilevered high aspect ratio wing with winglet were investigated. The configuration represented a current-technology, twin-engine airplane. Low- and high-speed models were used to evaluate compressibility effects through transonic Mach numbers and a wide range of mass-density ratios. Four flutter mechanisms were obtained in test and analysis from various combinations of configuration parameters.

86-44

Fundamental Aerodynamic Characteristics of Delta Wings with Leading-Edge Vortex Flows

R.M. Wood, D.S. Miller
NASA Langley Res. Ctr., Hampton, VA
J. Aircraft, 22 (6), pp 479-485 (June 1985), 15 figs, 40 refs

KEY WORDS: Aircraft wings, Aerodynamic loads

An investigation of the aerodynamics of sharp leading-edge delta wings at supersonic speeds has been conducted. The supporting experimental data for this investigation were taken from published force, pressure, and flow-visualization data in which the Mach number normal to the wing leading edge is always less than 1.0. The individual upper-and lower-surface nonlinear characteristics for uncambered delta wings are determined and presented in three charts.

86-45

Verification of a Computer Program for Vibration Analysis of Composite Wing Cores

Y. Noguchi, T. Ishikawa
National Aerospace Lab., Tokyo, Japan
Rept. No. NAL-TR-825, 24 pp (July 1984), N85-15187/6/GAR (In Japanese)

KEY WORDS: Aircraft wings, Composite structures, Flutter, Finite element technique, Computer programs

A finite element program developed for vibration analysis of composite wing cores was examined. Such cores are used in a research project on aeroelastic tailoring. The formulation of the finite element analysis is presented. Basic elastic moduli of composites are discussed to confirm their reliability of the input data for the verification. All moduli are determined by experimental procedures and theoretical bases of such experimentation are given.

86-46

Experimental Study on Transonic Flutter Characteristics of Sweptback Wing with Core Composite Plates Having Different Fiber Orientations

K. Isogai, H. Ejiri, T. Kikuchi, J. Nakamichi
National Aerospace Lab., Tokyo, Japan
Rept. No. NAL-TR-827, 12 pp (Aug 1984), N85-14842/7/GAR (In Japanese)

KEY WORDS: Aircraft wings, Plates, Composite structures, Flutter

The effects of fiber orientation on the transonic flutter characteristics of a sweptback wing with a core composite plate are examined experimentally. The two kinds of flutter model having the same planform but different bend-twist characteristics were made.

86-47

Influence of Fighter Aircraft Load Spectrum Variations on Fatigue Crack Initiation and Growth

E. Reinberg
Israel Aircraft Industries Ltd., Lod, Israel
Israel J. Tech., 22 (1), pp 39-44 (1984/85), 3 figs, 7 tables, 3 refs

KEY WORDS: Aircraft, Fatigue life

Experimental and analytical studies of spectrum sensitivity effects are reported. A typical high performance fighter aircraft load spectrum was used as a baseline. The spectrum variations ranged from realistic variations, that might be

expected among operational aircraft, to variations to investigate spectrum development and test procedures. Tests represented crack initiation and growth out of an open or a fastener filled hole in aluminium alloy 2014-T6 specimens.

86-48
First-Order Green's Function Approach to Supersonic Oscillatory Flow: A Mixed Analytic and Numeric Treatment
M.I. Freedman, S. Sipcic, K. Tseng
Boston Univ., Boston, MA
Rept. No. NASA-CR-172207, 38 pp (Feb 1985), N85-18002/4/GAR

KEY WORDS: Aircraft, Green function, Frequency domain method, Fluid-induced excitation

A frequency domain Green's function method for unsteady supersonic potential flow around complex aircraft configurations is presented. The focus is on the supersonic range wherein the linear potential flow assumption is valid. The Green's function method is employed in order to convert the potential flow differential equation into an integral one. This integral equation is then discretized, through standard finite element technique, to yield a linear algebraic system of equations relating the unknown potential to its prescribed co-normalwash (boundary condition) on the surface of the aircraft.

MISSILES AND SPACECRAFT

86-49
Development of a Dynamic Finite Element Model for Unrestrained Flexible Structures
E.R. Christensen, S.W. Lee
Univ. of Maryland, College Park, MD
Rept. No. AFOSR-TR-85-183, 145 pp (Oct 1984), AD-A151 176/5/GAR

KEY WORDS: Spacecraft, Translational response, Rotational response, Finite element technique

An efficient finite element model and solution technique have been developed; this is for the analysis of unrestrained flexible structures undergoing large elastic deformations coupled with grossnonsteady translational and rotational motions with respect to an inertial reference frame. The nonlinear coupled differential equations resulting from the finite element approximation are integrated timewise, using an implicit-explicit split operator numerical integration scheme which treats the stability sensitive terms of the equation implicitly while the rest of the equation is treated explicitly.

86-50
Vibration Analysis of a Multipurpose Platform
T. Hanawa, Y. Ohkami, E. Nakai, T. Tadakawa
National Aerospace Lab., Tokyo, Japan
Rept. No. NAL-TR-803, 42 pp (Apr 1984), N85-18078/4/GAR (In Japanese)

KEY WORDS: Spacecraft platforms, Energy methods

Some results are presented of the vibration analysis for simplified models of a multipurpose geostationary platform. For the detailed analysis, the finite element method is widely used but in a preliminary analysis the method described here is also useful since it is computationally tractable and easy to handle although there are constraints on the configuration complexity. A mission model is described for the proposed platform containing six missions of communication and broadcasting. Launch sequences and deployments of the platform, and mass and inertia properties of the constitutent models are briefly explained.

86-51
Modal Control of Structural Systems
D.F. Miller, W.R. Wells
Wright-State Univ., Dayton, OH
Rept. No. AFWAL-TR-84-3054, 32 pp (Nov 1984), AD-A149 734/6/GAR

KEY WORDS: Spacecraft, Modal control technique

This report discusses the control of flexible systems described by a generalized one-dimensional wave equation, which relates the structure displacement to the force distribution acting on the structure. Optimal control involving the minimization of a quadratic performance index representing control and modal energy content is considered. Typically this control formulation leads to a state feedback algorithm.

86-52
Flow-Induced Vibration of the Space Shuttle Main Engine Liquid-Oxygen Posts
S.S. Chen, J.A. Jendrzejczyk
Argonne National Lab., Argonne, IL
Rept. No. ANL-84-75, 77 pp (Sept 1984), DE-85004342/GAR

KEY WORDS: Space shuttle, Rocket engines, Fluid-induced excitation, Fatigue life

Cracking of liquid-oxygen (LOX) posts were observed in several evaluation tests. The design modification consists of attaching impingement shields to LOX posts in the upstream row. This has improved the vibration/fatigue problem of LOX posts. However, that modification resuklts in an increased pressure drop that ultimately affects the lifetime of other components. This report presents a preliminary assessment of the LOX post vibration problem including a review of relevant parameters, flow induced vibration mechanisms, scoping calculation and experiment, and a work plan for an integrated theoretical/experimental study.

BIOLOGICAL SYSTEMS

HUMAN

86-53
Response to a Reduction in Traffic Noise Exposure
A.L. Brown, A. Hall, J. Kyle-Little
Griffith Univ., Nathan, Brisbane 4111, Australia
J. Sound Vib., 98 (2), pp 235-246 (Jan 22, 1985), 4 figs, 1 table, 18 refs

KEY WORDS: Traffic noise, Noise reduction, Human response

Dose-response relationships for road traffic noise have previously been based on community response (annoyance) measured under relatively steady state Noise exposure conditions. A report of an examination of responses measured following a change in exposure is presented.

86-54
A Scale for Rate of Tactual Vibration
C.E. Sherrick
Princeton Univ., Princeton, NJ 08544
J. Acoust. Soc. Amer., 78 (1), pp 78-83 (July 1985), 5 figs, 4 tables, 29 refs

KEY WORDS: Human hand, Vibration response

Estimates were made by observers of the rate of mechanical vibrations presented to the finger as pulses ranging from 2 to about 300 pps. From the functions generated by this study, a set of ten values of mechanical vibration rate was selected. Additional observers were asked to learn to identify these values of rate. Information analysis of the data showed that when rate alone is varied, observers can identify between three and five items correctly; when rate and intensity are covaried redundantly, between five and eight items can be identified correctly.

86-55
Crash Survivability Analysis Computer Study
M. Fitzpatrick
Fitzpatrick Engrg., Warsaw, IN
Rept. No. DOT-HS-806 685, 130 pp (Apr 25, 1984), PB85-163079/GAR

KEY WORDS: Collision research (automotive), Crash victim simulation, Computer programs

This report documents the findings of a four month study in which a crash survivability envelope was derived for three basic vehicle sizes. The programs are DRACR for the driver and PAC for the right front passenger. The enhancements made to the programs were primarily the addition of a three-point belt restraint system to each program. Survivability limits for various occupant sizes, crash modes, and vehicle sizes are presented for both the driver and front seat passenger, when restrained by a seat belt and air bag and by an air bag only.

86-56
CAL-3D User Convenience Package Upgrades and CVS (Crash Victim Simulator) Program Studies of Occupant Equilibrium, Force Deflection Sensitivity and Accident Reconstruction
M.T. McGrath, D.J. Segal
MGA Res. Corp., Buffalo, NY
Rept. No. G38-V-3, DOT-HS-806 546, 128 pp (Jan 1984), PB85-166007/GAR

KEY WORDS: Collision research (automotive), Crash victim simulation

The CAL-3D crash victim simulator (CVS) is a powerful tool for the mathematical simulation of automobile crashes. In order to make the CAL-3D CVS easier to use, the user convenience package (UCP) was developed. An equilibrium study was performed to provide guidance to CAL-3D CVS users on occupant equilibrium with a vehicle. A force-deflection sensitivity study was performed to provide guidance in the development of data for the CVS through component testing. Two real world accidents were also simulated to demonstrate the capabilities of the CVS/UCP in accident reconstruction.

MECHANICAL COMPONENTS

ABSORBERS AND ISOLATORS

86-57
Aspects for the Selection of Silencer for Large Diesel Engines (Gesichtspunkte bei der Dimensionierung und Auswahl von Abgasschalldampfern fur grossere Dieselmotoren)
F. Fleischer
Friedrich-Ebert-Strasse 38, D-6945 Hirschberg 1
MTZ Motortech Z., 46 (5), pp 183-187 (May 1985), 11 figs, 4 refs

KEY WORDS: Silencers, Diesel engines

The criteria used for acoustic evaluation of silencers for large diesel engines are explained. A standardized spectrum of acoustic frequencies is proposed to be used as a reference base for comparing silencers. Using this frequency spectrum as a basis the reduction in the A-evaluated noise level and the frequency response of the noise damping provided by different types of silencers are discussed. The problems that arise when silencers are arranged in series are also described.

86-58
Vibration Isolator Actuator
R.L. Plante
Dept. of Air Force, Washington, DC
PAT-APPL-6-690 438/GAR, 14 pp (Jan 1985)

KEY WORDS: Vibration isolators

A novel actuator for controlling the position of a mirror segment of a segmented mirror assembly and for isolating the segment from vibration is described.

86-59
Temperature Field in Rubber Vibration Isolators
M.I. Abdulhadi
Yarmouk Univ., Irbid, Jordan
J. Sound Vib., 98 (3), pp 447-454 (Feb 8, 1985), 7 figs, 5 refs

KEY WORDS: Vibration isolators, Elastomers, Heat generation, Cyclic loading

The temperature field inside a vibrating rubber solid cylinder is investigated. The rubber cylinder, a specimen of a vibration isolator rubber, is subjected to a repeatedly cyclic compressive force by means of an electrodynamic shaker. The temperatures at 16 different locations inside the cylinder are measured by means of copper-constantan thermocouples. The values of the temperature found from the analytical investigation compare fairly well with the experimental measurements.

86-60
Measurement of Automotive Suspension Displacement Using Rotary Variable Differential Transformers
J.J. Jachman, D.G. Tauriainen
Ford Motor Co., Dearborn, MI
Experimental Mechanics, Proc. 1985 SEM Spring Conf., June 9-14, 1985, Las Vegas, NV, pp 258-262, 7 figs, 1 table

KEY WORDS: Suspension systems (vehicles), Displacement measurement

An improved method of measuring vertical displacement of automotive suspensions during vehicle operation is described. A rotary variable differential transformer mounted at the pivot of the suspension arm measures angular motion, which is proportional to linear displacement at the wheel. Accuracy is significantly improved by eliminating problems associated with other types of transducers.

86-61
Analytical and Experimental Studies of Wheelchair Suspension Systems

I.M. Allison
Univ. of Surrey, Guildford, Surrey, GU2 5XH, UK
Experimental Mechanics, Proc. of 1985 SEM Spring Conf., June 9-14, 1985, Las Vegas, NV, pp 785-791, 5 figs, 4 refs

KEY WORDS: Suspension systems (vehicles)

Experiments were conducted to determine the suspension stiffness of a conventional wheelchair and to explain the inadequate performance under shock loading. A description is given of a cross-country wheelchair which embodies a suspension system suitable for negotiating a 75mm step without undue discomfort for the occupant.

86-62
An Analysis of Pulse Control for Simple Mechanical Systems
Z. Prucz, T.T. Soong, A. Reinhorn
Modjeski and Masters, New Orleans, LA 70130
J. Dynam. Syst., Meas. Control, Trans. ASME, 107 (2), pp 123-131 (June 1985), 16 figs, 14 refs

KEY WORDS: Active control, Pulse excitation

An efficient pulse control method for insuring safety of simple mechanical systems is developed; its sensitivity to the excitation frequency content and to various control parameters is studied. The control algorithm, consisting of applying pulse forces in a feedback fashion, is designed to insure that maximum system response is limited to safe values at all times. The proposed algorithm is simple to implement and is efficient in controlling peak response in terms of on-line computation and pulse energy required. The technique is illustrated and analyzed for a single-degree-of freedom linear system.

86-63
On the Suppression of Ground Vibration by Active Force Controller (2nd Report; Optimum Design of the Active Force Controlling System)
N. Tanaka, Y. Kikushima
Mechanical Engrg. Lab. 1-2 Namiki Tsukuba Science City 305, Japan
Bull. JSME, 28 (241), pp 1481-1488 (July 1985), 9 figs, 14 refs

KEY WORDS: Active force control, Ground vibration, Machine foundations

To eliminate ground vibration as pollution, a systematic design procedure of an active force control system is presented. From the viewpoint of feedback control, the active force control system with a series-type dynamic compensator is constructed. An iterative algorithm based upon the quasi-Newton method is proposed. The characteristics of the system are discussed and the effectiveness of suppressing the exciting force is compared with the result of the feedforward control method.

86-64
Analysis of the Effect of Mass Unbalances and Assembly Tolerances on the Performance of the Four-Axis Stabilized Director Mount
J. Hayward
Weapons Systems Res. Lab., Adelaide, Australia
Rept. No. WSRL-355-TR, 83 pp (May 1984), AD-A151 481/9/GAR

KEY WORDS: Mountings, Weapons systems, Unbalanced mass response

A necessary component of many weapon systems is the stabilized mechanical mount, used for directing the boresight of sensors and designators and the launching rails of weapons. It must be able to point the boresight accurately in any direction despite the inevitable changes in attitude adopted by the carrying vehicle. Two axes of motion between vehicle and boresight is the minimum number required, but practical considerations often result in the use of three or four axes. The most commonly used arrangement is that of the elevation-over-azimuth-over-pitch-over-roll, four-axis mount. This report analyzes that type of director mount to determine the torques generated by mass unbalances about the motor driven axes.

86-65
First Passage of a Sliding Rigid Structure on a Frictional Foundation
L.A. Bergman, B.F. Spencer, Jr.
Univ. of Illinois, Urbana-Champaign, IL
Earthquake Engrg. Struc. Dynam., 13 (3), pp 281-291 (May/June 1985), 3 figs, 2 tables, 16 refs

KEY WORDS: Base isolation, Seismic excitation, Structure-foundation interaction

The first passage problem for a sliding rigid block on a frictional foundation, subjected to Gaussian white noise through the foundation, is

studied. A well-posed boundary value problem is formulated from Markov process theory and solved for the ordinary moments of time to first passage by the finite element method. A range of parameters is studied representing a simple seismic base isolation system. Results of Monte Carlo simulation are given for comparison

86-66
Measurement of Shock-Absorption Characteristics of Athletic Shoes
C.A. Calder, C.E. Smith, J. Ying
Oregon State Univ., Corvallis, OR
Exptl. Tech., 9 (6), pp 21-24 (June 1985), 6 figs, 7 refs

KEY WORDS: Shock absorption, Elastomers, Human response

Athletic shoes, including jogging trainers and basketball or court shoes, can be tested and compared for shock-absorption capability using an impact-test approach and measuring the peak force, or shock, transmitted through the sole. Although the test method does not precisely model the loading situation in actual running and jumping, it does give dynamic peak forces of a similar magnitude. The method permits direct comparison of the shock-absorption capability of various brands and styles of athletic shoes with a highly repeatable test and at minimal cost.

BLADES

86-67
Hybrid Vibration-Mode Analysis of Rotating Turbine-Blade Models
E. Vogt, J. Geldmacher, B. Dirr, H. Kreitlow
Univ. of Hannover, Fed. Rep. Germany
Exptl. Mech., 25 (2), pp 161-170 (June 1984), 13 figs, 10 refs

KEY WORDS: Turbine blades, Natural frequencies, Mode shapes, Holographic techniques, Interferometric techniques

In addition to several holographic measuring methods, a new method has been developed to determine the vibration modes of blades in general, especially for a rotating blade. The object-related laser triggering method, which yields interferograms without using an image derotator, thus avoiding special alignment of the derotator axis and machine axis is described.

86-68
Flow Field and Acoustics of Two-Dimensional Transonic Blade-Vortex Interaction
A.R. George, S.B. Chang
Cornell Univ., Ithaca, NY
Rept. No. ARO-17425.3-EG, 49 pp (Oct 17, 1984), AD-A150 035/4

KEY WORDS: Propeller blades, Helicopters, Vortex shedding

Blade-vortex interaction noise from full-scale helicopters is shown to involve unsteady transonic flow phenomena which can be modeled as two-dimensional. An unsteady, small-disturbance-theory, numerical analysis, is used to model the interaction of an airfoil with a finite-core, locally-convected vortex using the vortex-in-cell method with multiple branch cuts accounting for the distributed vortices potential jumps. The effects of airfoil shape, angle of attack, Mach number, vortex strength, and vortex miss distance on the flow and on waves radiated forward are investigated.

86-69
The Effect of Acoustically Lined Walls on Cascade Flutter
T. Watanabe, S. Kaji
Univ. of Tokyo, Tokyo, Japan
Bull. JSME, 28 (241), pp 1359-1366 (July 1985), 13 figs, 6 refs

KEY WORDS: Blades, Cascades, Vibration control, Walls, Acoustic linings

The effect of acoustically lined walls on cascade flutter is investigated theoretically using a semi-actuator disk model, which permits the considerations for flow turning and total-pressure-loss due to cascades. The three-dimensional flow fields, upstream, inside and downstream of the cascade are solved separately, and then joined properly at the leading edge plane and the trailing edge plane. The acoustic characteristics of walls in each region are specified by the uniform acoustic admittance.

86-70
Comparison of Measured and Predicted Unsteady Pressure on a Fan Blade in Unstalled Supersonic Flutter
M.J. Brooker, D.G. Halliwell
Rolls-Royce Ltd., Derby, UK
Rept. No. PNR-90223, 16 pp (Sept 1, 1984), N85-16839/1/GAR

KEY WORDS: Fan blades, Flutter

Measurements on a transonic fan vibrating in a coupled flutter mode are compared with finite element predictions, in terms of unsteady amplitude and phase angle of the blade surface pressures. Unsteady effects on the blade section are studied, and the separate lift and moment contributions are identified. Using measured results the variation of these parameters with radius is examined.

BEARINGS

86-71
The Elastohydrodynamic Solution of Journal Bearings Under Dynamic Loading
K.P. Oh, P.K. Goenka
General Motors Res. Labs., Warren, MI 48090
J. Tribology, Trans. ASME, 107 (3), pp 389-395 (July 1985), 13 figs, 14 refs

KEY WORDS: Journal bearings, Lubrication, Elastohydrodynamic properties, Newton-Raphson method, Finite element technique

The Newton-Raphson algorithm was used in conjunction with Murty's algorithm and the finite-element method to analyze the elastohydrodynamic lubrication of a journal bearing under dynamic loading. Cavitation boundary conditions were used. A realistic compliance matrix and load schedule were used in the illustrative example. Solutions for the film pressure, the film thickness and its rate of change with time were obtained as functions of the crank angle.

86-72
Numerical Simulation of Dynamically Loaded Flexible Short Journal Bearings
L. van der Tempel, H. Moes, R. Bosma
SWDiesel, Amsterdam, The Netherlands
J. Tribology, Trans. ASME, 107 (3), pp 396-401 (July 1985), 11 figs, 13 refs

KEY WORDS: Journal bearings, Lubrication, Elastohydrodynamic properties, Newton-Raphson method, Direct computational method

A numerical method is proposed for calculating film thicknesses in flexible short journal bearings under dynamic load. The system of elastohydrodynamic integro-differential equations is discretized directly and solved by a 2-step Newton-Raphson method. The cavitation boundaries are located by a special discretization of the pressure. This type of condition puts practically no restrictions on the boundary alterations. The results for the con rod bearings of medium-and high-speed combustion engines are compared.

86-73
A New Fatigue Life Model for Rolling Bearings
E. Ioannides, T.A. Harris
SKF Engrg. & Res. Ctr., Nieuwegein, The Netherlands
J. Tribology, Trans. ASME, 107 (3), pp 367-378 (July 1985), 17 figs, 22 refs

KEY WORDS: Rolling contact bearings, Fatigue life

A novel model for the prediction of fatigue life in rolling bearings is described. Central to this model is the postulation of a statistical relationship between the probability of survival, the fatigue life, and a stress-related fatigue criterion level above a fatigue limit for an elementary volume of material in the bearing. Using this concept, the stress volume to fatigue and the fatigue life of the bearing can be calculated for different loads, material and operating conditions.

86-74
The Dynamics of Ball Separators in Ball Bearings — Part 1: Analysis
C.R. Meeks, K.O. Ng
Hughes Aircraft Co., El Segundo, CA
ASLE, Trans., 28 (3), pp 277-287 (July 1985), 7 figs, 11 refs

KEY WORDS: Ball bearings, Impact response

The dynamic equations of motion of a ball-bearing separator are solved with a six degree-of-freedom model and vector matrix algebra. The dynamic model includes the effects of inelastic collisions of the separator with the balls and/or

races, and also slip of the balls on the races. The digital computer model predicts separator motions, impact forces, frequencies, and all dynamic variables such as accelerations, velocities, and energy losses.

86-75
The Dynamics of Ball Separators in Ball Bearings — Part II: Results of Optimization Study
C.R. Meeks
Hughes Aircraft Co., El Segundo, CA
ASLE, Trans., 28 (3), pp 288-295 (July 1985), 16 figs, 1 table, 7 refs

KEY WORDS: Ball bearings, Optimization, Impact response

The dynamic equations of motion of ball-bearing separators were solved using certain simplifications to make computer analysis feasible from a cost point of view. A typical turbine engine bearing employing solid lubrication was used for a trade-off and optimization study of ball-separator design. The effects of varying geometric parameters of the separator were studied, along with different friction and traction coefficients and operating speeds of the bearing.

GEARS

86-76
Vibrational Characteristics of Friction Between Gear Teeth
H. Iida, A. Tamura, Y. Yamada
Tokyo Inst. of Technology, Tokyo, Japan
Bull. JSME, 28 (241), pp 1512-1519 (July 1985), 17 figs, 3 refs

KEY WORDS: Gears, Friction excitation, Vibration response

An investigation into the vibrational characteristics of the friction between gear teeth is presented.

FASTENERS

86-77
An Experimental Study of the Reflection and Transmission of Flexural Waves at a T-Joint
J.F. Doyle, S. Kamle
Purdue Univ., West Lafayette, IN
Experimental Mechanics, Proc 1985 SEM Spring Conf., June 9-14, 1985, Las Vegas, NV, pp 560-564, 9 figs, 2 refs

KEY WORDS: Joints, Flexural waves, Wave reflection, Wave transmission

Further developments of an experimental methodology for analyzing the effect of structural joints on wave propagation are presented. Experimental results for a T-joint are discussed, as well as improved ways of characterizing the incident wave.

86-78
The Control of the Clamping Force Variation in High Strength Friction Grip Bolted Joints
W. Stiefel, M. Groper, J. Hamelink
Western Michigan Univ., Kalamazoo, MI
Experimental Mechanics, Proc. 1985 SEM Spring Conf., June 9-14, 1985, Las Vegas, NV, pp 548-552, 7 figs, 8 refs

KEY WORDS: Bolted joints

Using a direct method for measuring the preload in bolts, the variation of the clamping force in high strength friction grip bolted joints was determined during static and dynamic loading, including shocks. It was found that the decrease of this clamping force with time and during repeated loading reaches asymptotically some limits which mainly depend upon the type of loading.

86-79
Equivalent Damping Ratio for High Strength Friction Grip Bolt Jointed Structures
M. Groper, W. Stiefel, J. Hamelink
Western Michigan Univ., Kalamazoo, MI
Experimental Mechanics, Proc. 1985 SEM Spring Conf., June 9-14, 1985, Las Vegas, NV, pp 87-90, 3 figs, 7 refs

KEY WORDS: Bolted joints, Equivalent viscous damping, Seismic response, Buildings

A global damping ratio for a single high strength friction grip bolt jointed structure is determined considering an equivalent damping ratio for the dissipation of energy in the structure's elements. The measured damping ratio is compared with

the equivalent damping ratio calculated from the dissipation of energies of the structure's elements.

86-80
Analysis of Corrosion Fatigue Crack Growth in Welded Tubular Joints
S.J. Hudak, Jr., O.H. Burnside, K.S. Chan
Southwest Res. Inst., San Antonio, TX 78284
J. Energy Resources Tech., Trans. ASME, 107 (2), pp 212-219 (June 1985), 12 figs, 1 table, 42 refs

KEY WORDS: Welded joints, Tubes, Fatigue life, Crack propagation

An improved fracture mechanics model for fatigue crack growth in welded tubular joints is developed. Primary improvements include the use of a wide-ranged equation for the fatigue crack growth rate properties, and the incorporation of the influence of local weld-toe geometry into the stress intensity factor equations.

86-81
Fatigue of Weldments Under Combined Bending and Torsion
J.-Y. Yung, F.V. Lawrence, Jr.
Univ. of Illinois, Urbana-Champaign, IL
Experimental Mechanics, Proc. 1985 SEM Spring Conf., June 9-14, 1985, Las Vegas, NV, pp 646-648, 7 figs, 4 refs

KEY WORDS: Welded joints, Fatigue tests, Fatigue life, Finite element technique

As welded and stress-relieved tube-to-plate weldments were fatigue tested under combined bending and torsion. Compressive residual stresses were found to exist at the weld toe. Finite element methods were used to calculate notch-root stresses and strains. An analytical model was developed to predict the fatigue life.

86-82
The Measurement of Fatigue Cracks at Spot-Welds
J.F. Cooper, R.A. Smith
Cambridge Univ., Cambridge, UK
Intl. J. Fatigue, 7 (13), pp 137-140 (July 1985), 7 figs, 6 refs

KEY WORDS: Welded joints, Fatigue life

Current fabrication changes in the automotive industry have stimulated interest in fatigue avoidance at spot-welded joints. Basic endurance data are available only for specific specimen types; a generalized fracture mechanics approach has been impeded by lack of crack propagation data. A direct current potential difference technique for the continuous measurement of crack dimensions in spot-welded mild steel specimens under the fatigue loadings is described.

86-83
On the Elastodynamic Behaviour of Thin Bonds
R.C. Bhattacharya
Projects and Development India Limited, Sindri, Dhanbad 828122, India
J. Sound Vib., 99 (2), pp 225-234 (Mar 22, 1985), 3 figs, 9 refs

KEY WORDS: Elastodynamic response, Wave propagation

Improved bond equations for the study of elastodynamic behavior of thin bonding layers between two elastic media are devised. These equations take both inertia and elasticity of the bonding material into account and consequently are of wide applicability.

SEALS

86-84
Rotordynamic Coefficients for Compressible Flow in Tapered Annular Seals
C.C. Nelson
Texas A & M Univ., College Station, TX
J. Tribology, Trans. ASME, 107 (3), pp 318-325 (July 1985), 2 figs, 5 tables, 11 refs

KEY WORDS: Seals, Stiffness coefficients, Damping coefficients

Derivation of the governing equations for compressible flow in a tapered annular seal is based on Hirs' turbulent bulk-flow model. Zeroth and first-order perturbation equations are developed by an expansion in the eccentricity ratio. These equations are numerically integrated to obtain the leakage, and the direct and cross-coupled stiffness and damping coefficients. Seal parameters

similar to the space shuttle main engine high pressure oxidizer turbopump are used to demonstrate output from the analysis procedure.

86-85
Convergent-Tapered Annular Seals: Analysis and Testing for Rotordynamic Coefficients
D.W. Childs, J.B. Dressman
Texas A & M Univ., College Station, TX
J. Tribology, Trans. ASME, 107 (3), pp 307-317 (July 1985), 8 figs, 4 tables, 15 refs

KEY WORDS: Seals, Stiffness coefficients

A combined analytical-computational method is developed to calculate the pressure field and dynamic coefficients for tapered high-pressure annular seals, typical of neck-ring and interstage seals employed in multistage centrifugal pumps. Completely developed turbulent flow is assumed in both the circumferential and axial directions and is modeled by Hirs' bulk-flow turbulent-lubrication equations.

STRUCTURAL COMPONENTS

BEAMS

86-86
Dispersive Bending Waves in Uniform Bars
A.K. Roy, R. Plunkett
Univ. of Minnesota, Minneapolis, MN
Experimental Mechanics, Proc. 1985 SEM Spring Conf., June 9-14, 1985, Las Vegas, NV, pp 527-531, 4 figs, 7 refs

KEY WORDS: Beams, Flexural waves

The traveling bending waves in a long beam of rectangular cross section were measured and calculated. The bending waves were induced by impacting with a steel sphere and measured with strain gages at several distances from the point of impact. The impact force was calculated as a function of time by integrating the dynamic equations of the sphere and the beam. The force spectrum was then found by an FFT calculation and multiplied by the moment frequency response of the beam to get the moment spectrum. The moment time function was calculated by an inverse FFT.

86-87
Forced Vibrations of a Beam with One-Sided Amplitude Constraint: Theory and Experiment
S.W. Shaw
Michigan State Univ., East Lansing, MI
J. Sound Vib., 99 (2), pp 199-212 (Mar 22, 1985), 10 figs, 25 refs

KEY WORDS: Beams, Constrained structures, Periodic excitation

An elastic beam with one-sided amplitude constraint subjected to periodic excitation is considered. Experimental results are obtained and compared with results given by a theoretical model based on a single mode analysis of the beam. This model is a single degree of freedom oscillator with periodic excitation and a piecewise linear restoring force. This single mode model is shown to provide good overall qualitative information about the actual physical system. It predicts the multiple subharmonic resonances, period doublings, and some chaotic regimes found experimentally.

86-88
The Maximum Controlled Follower Force on a Free-Free Beam Carrying a Concentrated Mass
Y.P. Park, C.D., Jr. Mote
Univ. of California, Berkeley, CA
J. Sound Vib., 98 (2), pp 247-256 (Jan 22, 1985), 8 figs, 8 refs

KEY WORDS: Beams, Bernoulli-Euler method, Follower forces

A uniform, free-free, Euler-Bernoulli beam, transporting a concentrated mass with rotary and transverse inertia, is driven by a follower force with controlled direction. A finite element model of the beam transverse motion in the plane is formulated through the extended Hamilton's principle. The stability of the model is investigated. Both divergence and flutter instabilities can occur over the range of beam models examined.

86-89
Inelastic Behaviour of Rectangular Beams Subjected to Steady Axial Load and Cyclic Bending

J.J. Webster, S.J. Hardy, T.H. Hyde
The University, Nottingham, UK
Intl. J. Mech. Sci., 27 (4), pp 257-271 (1985), 11 figs, 8 refs

KEY WORDS: Rectangular beams, Axial excitation, Cyclic loading

Analytical and numerical solutions are given for the inelastic behavior of a rectangular cross-section beam, subjected to a steady axial load and cyclic, fully reversed load-controlled bending. Elastic-perfectly plastic, linear isotropic and kinematic materials are examined and solutions for the strain accumulation and cyclic reverse plastic strains obtained. The effect of introducing a creep dwell period into the cycle is considered.

86-90
The Direct (Natural) Reduction Method (Das direkte ((naturliche)) Reduktionsverfahren
S. Falk
Technische Universitat Braunschweig, Fed. Rep. Germany
Acta Mech., 54 (1-2), pp 49-62 (Dec 1984), 5 figs, 22 refs (In German)

KEY WORDS: Beams, Reduction methods

A method of reduction is carried out for a straight beam without using transfer matrices. The so-called direct way improves numerical stability without restrictions and reduces the numerical effort for a small number of sections. An example is included to demonstrate the natural method.

86-91
A Note on the Dynamical Behaviour of Uniform Beams Having Open Channel Section
R.E.D. Bishop, W.G. Price, Zhang Xi-Cheng
Dalian Inst. of Technology, People's Rep. of China
J. Sound Vib., 99 (2), pp 155-167 (Mar 22, 1985), 1 fig, 4 tables, 15 refs

KEY WORDS: Beams, Timoshenko theory, Natural frequencies, Mode shapes

Theoretical predictions of the natural frequencies and mode shapes of beams depend on the choice of beam theory adopted in the mathematical model. The finite element approach may be used and this depends on the mathematical modeling of the structure. The dynamic characteristics of coupled lateral bending and twisting in uniform beams of channel section have been investigated, and the purpose of this paper is to bring much of the relevant data together. Comparisons are made between theoretical predictions and measured natural frequencies.

86-92
Sound Radiation from Flexible Blades
S.A.L. Glegg
Univ. of Southampton, Southampton, UK
J. Sound Vib., 98 (2), pp 171-182 (Jan 22, 1985), 5 figs, 8 refs

KEY WORDS: Blades, Cantilever blades, Hydrodynamic loads, Sound waves, Wave radiation

The sound radiation from fluctuating hydrodynamic loads on flexible cantilever beams is discussed. It is shown that when the beam moves in response to the applied load, the sound radiation can be significantly changed.

86-93
Acoustic Radiation Generated by Local Excitation of Submerged Beams and Strings
J. Song, A.N. Norris, J.D. Achenbach
Northwestern Univ., Evanston, IL
J. Sound Vib., 100 (1), pp 107-121 (May 8, 1985), 10 figs, 1 table, 14 refs

KEY WORDS: Beams, Strings, Submerged structures, Sound waves, Wave radiation

Free and forced motions of submerged one-dimensional waveguides are investigated. Both the submerged beam and the submerged string can support a wave system which includes a pure surface wave in the fluid adjoining the waveguide, provided that certain conditions on the frequency (for the beam) or the physical parameters of the system (for the string) are satisfied. Dispersion curves are presented for steel beams and steel strings in water. Steady-state solutions are derived for excitation by a concentrated time-harmonic load. The displacement responses at the point of application of the load and in the far field are examined.

86-94
Interply Layer Degradation Effects on Composite Structural Response

C.C. Chamis, G.C. Williams
NASA Lewis Res Ctr., Cleveland, OH
J. Aircraft, 22 (7), pp 573-580 (July 1985), 18 figs

KEY WORDS: Composite beams, Layered materials

Recent research activities to computationally evaluate the effects of interply layer progressive weakening (degradation) on the structural response of a composite beam are summarized. The structural responses of interest include bending, buckling, free vibrations, periodic excitation, and impact. Finite element analysis was used for the computational evaluations.

86-95
The Free Vibration of Compact Rotating Radial Cantilevers
C.H.J. Fox
Univ. of Nottingham, Nottingham, UK
J. Sound Vib., 98 (3), pp 325-336 (Feb 8, 1985), 7 figs, 1 table, 18 refs

KEY WORDS: Cantilever beams, Coupled response, Natural frequencies, Mode shapes

The free vibration of rotating uniform radial cantilever beams of compact cross section is considered, with account taken of centrifugal coupling between motions in the principal elastic planes. For cases other than those in which the principal elastic axes coincide with the equatorial and meridional planes, the centrifugal coupling is shown to modify the vibrational behavior of the compact beam when compared to that of a beam which is infinitely stiff in one principal plane. This can result in a considerable reduction in fundamental natural frequency.

86-96
Errors in Response Calculations for Beams
H. Wada, G.B. Warburton
Univ. of Nottingham, Nottingham, UK
Earthquake Engrg. Struc. Dynam., 13 (3), pp 293-306 (May/June 1985), 4 figs, 4 tables, 13 refs

KEY WORDS: Cantilever beams, Error analysis, Normal modes, Newmark method, Laplace transformation

When the finite element method is used to idealize a structure, its dynamic response can be determined from the governing matrix equation by the normal mode method or by one of the many approximate direct integration methods. In either method the approximate data of the finite element idealization are used, but further assumptions are introduced by the direct integration scheme. It is the purpose of this paper to study these errors for a simple structure.

CYLINDERS

86-97
Vortex-Induced Response of a Flexible Cylinder in a Constant Current
N.M. Patrikalakis, C. Chryssostomidis
Massachusetts Inst. of Tech., Cambridge, MA
J. Energy Resources Tech, Trans. ASME, 107 (2), pp 244-249 (June 1985), 2 figs, 25 refs

KEY WORDS: Cylinders, Fluid-induced excitation, Vortex-induced vibration, Marine risers

A method is developed for theoretical prediction of the static and lift responses of a flexible cylinder in a unidirectional constant current. The theoretical prediction is based on information derived from experimental results involving rigid cylinders forced to oscillate sinusoidally orthogonally to a uniform stream. The approach allows the prediction of a number of independently determined, monochromatic and multimode dynamic solutions.

86-98
Flow-Induced Vibrations of a Circular Cylinder Due to Turbulent Internal Flows
H. Chung
Argonne National Lab., Argonne, IL
Rept. No. CONF-850219-1, 16 pp (1985), DE-85002766/GAR

KEY WORDS: Circular cylinders, Flow-induced vibration, Turbulence

Flow-induced vibration characteristics are experimentally investigated for a circular cylinder subjected to a turbulent internal flow. Analytical studies and modal analysis testing were also performed to investigate the free vibration characteristics of the cylinder in air and in fluid. The obtained free vibration characteristics were used to aid interpretation of the flow-induced vibration test results.

86-99
Determination of Fluid Damping Using Random Excitation
J.C.S. Yang, C.H. Marks, J. Jiang, D. Chen
Univ. of Maryland, College Park, MD
J. Energy Resources Tech., Trans. ASME, 107 (2), pp 220-225 (June 1985), 6 figs, 1 table, 14 refs

KEY WORDS: Circular cylinders, Submerged structures, Damping coefficients, Random decrement technique

An experimental investigation has been carried out to verify the validity of the use of the random decrement technique to determine the damping coefficients for a circular cylinder oscillating in water. Comparison with other data shows that the random decrement method yields comparable damping coefficients to those obtained using the logarithmic decrement technique for the range of variables in this experiment.

86-100
An Experimental Study of the Drag and Inertia Coefficients of a Freely Responding Cylinder Driven with Sinusoidal Motion in Still Water
K.G. McConnell, Qunying Jiao
Iowa State Univ., Ames, IA 50011
Experimental Mechanics, Proc. of 1985 SEM Spring Conf., June 9-14, 1985, Las Vegas, NV, pp 535-540, 10 figs, 16 refs

KEY WORDS: Cylinders, Underwater structures, Drag coefficients, Inertial forces, Periodic excitation

The drag and the inertia coefficients of the in-line force were determined experimentally based on the Morison equation. The interrelationship of the in-line force coefficients with the frequency ratio, the amplitude ratio, and the y-direction response were carefully examined.

86-101
On the Longitudinal Wave Propagation in Solid Elastic Cylinders
R.C. Bhattacharya
F.P.D.I.L., Sindri, Dhanbad, Bihar, 828122, India
Rev. Roumaine Sci. Tech., Mecanique Appl., 29 (5), pp 535-543 (1984) 4 figs, 2 tables, 12 refs

KEY WORDS: Cylinders, Wave propagation

An experimental study of longitudinal elastic wave propagation in solid circular cylinders is performed utilizing the pulse technique. Observations are interpreted in terms of the theoretical results. Characteristics of the propagation of elastic waves in cylinders for short source to receiver distances are discussed.

86-102
Analysis of the Stress State Due to Impulsive Loading in Cylindrical Rods
P.M. Calderale, V. Vullo, C.G. Mammola
Politecnico di Torino, Torino, Italy
Meccanica, 20 (1), pp 71-78 (Mar 1985) 9 figs, 21 refs

KEY WORDS: Cylinders, Impulse response, Finite element technique

An analysis of the state of stress of two coaxial cylindrical rods of different length, subjected to longitudinal impulsive loads is presented. Two different methods of general validity are used, the first based on the one-dimensional theory of longitudinal impact; the second on finite element procedures which have been specifically adapted to a much more complete picture of the state of stress.

FRAMES AND ARCHES

86-103
On the Dynamics of Framed Structures
E.A. Sadek
Cairo Univ., Egypt
Computers Struc., 20 (6), pp 1013-1019 (1985) 4 figs, 3 tables, 4 refs

KEY WORDS: Framed structures, Eigenvalue problems, Dynamic stiffness

A comparison is presented between the eigenvalues of a structure obtained using the distributed mass-stiffness technique and those obtained using a static stiffness matrix coupled with a mass matrix, both based on the same shape function (consistent mass matrix). Suggestions for improving the results obtained using the latter method are included.

86-104
Static and Cyclic Behaviours of Multistorey Infilled Frames with Different Interface Conditions

T.C. Liauw, K.H. Kwan
Univ. of Hong Kong, Hong Kong
J. Sound Vib., 99 (2), pp 275-283 (Mar 22, 1985) 5 figs, 3 tables, 8 refs

KEY WORDS: Multistory buildings, Frames, Cyclic loading

Results are presented from a study aimed at a deeper understanding of the static and cyclic behavior of non-integral, partially integral and integral infilled frames. Load-deflection behavior, stress distribution and collapse modes under static loads are examined and hysteretic characteristics, energy dissipation capacities, and degradation properties under cyclic loads are evaluated.

86-105
Reinforced Concrete Models for Seismic Response
C.D. Mercer, J.B. Martin
Cape Town Univ., South Africa
Rept. No. TR-41, 20 pp (Nov 1983) PB85-164408/GAR

KEY WORDS: Frames, Reinforced concrete, Seismic response

Reinforced concrete frames subjected to earthquake motions can exhibit considerable nonlinear behavior. Some simple and complex models for the reinforced concrete members, incorporating hysteresis rules to account for the highly nonlinear behavior have been developed. They enable the analyst to model more accurately the response of the frame to earthquake motions. Recent developments in this field are reviewed.

MEMBRANES, FILMS, AND WEBS

86-106
Free Vibration of Composite Membranes with Arbitrary Shape
K. Nagaya, Y. Hai
Gunma Univ., Kiryu, Gunma 376, Japan
J. Sound Vib., 100 (1), pp 123-134 (May 8, 1985) 6 figs, 4 tables, 22 refs

KEY WORDS: Membranes, Composite structures, Natural frequencies

A method for solving problems of a composite membrane with an arbitrarily shaped outer boundary and an arbitrarily shaped inner boundary is presented. The boundary conditions and the conditions of continuity are satisfied directly by using a Fourier expansion collocation method. The general equation for finding the natural frequencies of the composite membranes is presented.

86-107
Radiation of Sound from a Vibrating Annular Drum
S. De
National Res. Inst., Bankura, W. Bengal, India
J. de Mecanique Theor. Appl., 4 (3), pp 409-421 (1985) 6 figs, 7 tables, 18 refs

KEY WORDS: Membranes, Baffles, Sound waves, Wave radiation

The spatial distribution of sound from an annular drum vibrating in an infinite rigid plane is studied. The directional characteristics and the pressure of sound at any point radiated by the drum are discussed.

PANELS

86-108
Structural Response and Acoustic Fatigue for Random Progressive Waves and Diffuse Fields
C.E. Wallace
Arizona State Univ., Tempe, AZ
J. Spacecraft Rockets, 22 (3), pp 340-344 (May/June 1985) 12 figs, 12 refs

KEY WORDS: Panels, Honeycomb structures, Fatigue life, Acoustic excitation

The analysis of fatigue life under random acoustic loading is presented for honeycomb panels subjected to progressive waves and diffuse fields. The progressive wave loading simulates the environment associated with the liftoff of the Shuttle, while the diffuse loading approximates the environment in an acoustic test chamber. Numerical results are presented for honeycomb panels that allow one to readily observe the effects of various parameter changes.

86-109
Nonlinear Response of Double Wall Sandwich Panels
H.-K. Hong, R. Vaicaitis
Columbia Univ., New York, NY
J. Struc. Mech., 12 (4), pp 483-503 (1984/85) 13 figs, 29 refs

KEY WORDS: Sandwich panels, Modal analysis, Monte Carlo method, Viscoelastic core-containing media, Random excitation

An analytical study is presented to predict the nonlinear response of a double wall sandwich panel system that is subjected to random-type loading. Viscoelastic and nonlinear spring-dashpot models are chosen to characterize the behavior of the core. The nonlinear panel response is obtained by utilizing model analyses and Monte Carlo simulation techniques. Numerical results include the response spectral densities, root-mean-square responses, and probability density function histograms.

PLATES

86-110
The Nearfield Response of a Line-Driven Fluid-Loaded Plates
D. Feit, Y.N. Liu
David W. Taylor Naval Ship Res. & Dev. Ctr., Bethesda, MD 20084
J. Acoust. Soc. Amer., 78 (2), pp 763-766 (Aug 1985) 7 figs, 9 refs

KEY WORDS: Plates, Fluid-induced excitation, Submerged structures, Near-field region

A line-driven fluid-loaded elastic plate is considered. The plate response and radiated pressure field are obtained by a numerical evaluation of the Fourier integral representations of the solution for frequencies below and above coincidence.

86-111
Ray, Mode, and Hybrid Options for Source Excited Propagation in an Elastic Plate
I.T. Lu, L.B. Felsen
Polytechnic Inst. of New York, Farmingdale, NY 11735
J. Acoust. Soc. Amer., 78 (2), pp 701-714 (Aug 1985) 14 figs, 1 table, 8 refs

KEY WORDS: Plates, Impact response

Impact excited vibrations in a multiwave layer can be represented in terms of ray fields or of normal mode fields. At early observation times, multiply reflected ray fields can be distinguished by their different arrivals whereas at later times, their collective effect is best expressed by the normal modes. Instead of utilizing rays or modes separately, a recently developed hybrid theory for multiwave layered media permits both to be combined self-consistently and in convenient proportions. The hybrid formulation is based on a ray-mode equivalent whereby a given slowness spectral interval can be filled either with rays or with modes subject to a spectral remainder. Numerical results confirm the validity of the ray-mode equivalent and establish conditions where the hybrid scheme offers an attractive option.

86-112
Free Vibration of Plated Structures by Grillage Method
T. Balendra, N.E. Shanmugam
National Univ. of Singapore, Singapore 0511
J. Sound Vib., 99 (3), pp 333-350 (Apr 8, 1985) 12 figs, 7 tables, 14 refs

KEY WORDS: Plates, Grillage method

Free vibration of plated structures such as plates, stiffened plates and cellular structures are analyzed by the grillage method. The accuracy of the method is assessed by comparing with published results and those of the finite element method. Using this method the influence of the number of stiffeners in a stiffened plate and the number of webs in a cellular structure on the vibration characteristics of plated structures is investigated.

86-113
Natural Frequencies of Free, Orthotropic Elliptical Plates
Y. Narita
Hokkaido Inst. of Tech., Teine Maeda, Sapporo 061-24, Japan
J. Sound Vib., 100 (1), pp 83-89 (May 8, 1985) 3 figs, 14 refs

KEY WORDS: Plates, Natural frequencies, Flexural vibration, Ritz method

The transverse vibration of free elliptical plates with rectangular orthotropy is analyzed. A Ritz method analysis is carried out using a complete power series as a trial function. In the numerical examples the accuracy of the solution is carefully examined by a convergence test and comparisons with both analytical and experimental results in the isotropic case, and natural frequencies are obtained for a range of aspect ratios.

86-114
Stability and Vibration of Isotropic, Orthotropic and Laminated Plates According to a Higher-Order Shear Deformation Theory
J.N. Reddy, N.D. Phan
Virginia Polytechnic Institute and State Univ., Blacksburg, VA 24061
J. Sound Vib., 98 (2), pp 157-170 (Jan 22, 1985) 5 figs, 7 tables, 16 refs

KEY WORDS: Plates, Natural frequencies, Buckling, Elastic properties, Transverse shear deformation effects

A higher-order shear deformation theory is used to determine the natural frequencies and buckling loads of elastic plates. The theory accounts for parabolic distribution of the transverse shear strains through the thickness of the plate and rotary inertia. Exact solutions of simply supported plates are obtained and the results are compared with the exact solutions of three-dimensional elasticity theory, the first-order shear deformation theory, and the classical plate theory.

86-115
Small Amplitude Vibration of Viscoelastic Plates
S.A. Trogdon
Univ. of Nebraska, Lincoln, NE 68588
Acta Mech., 53 (3-4), pp 233-243 (Nov 1984) 2 figs, 4 refs

KEY WORDS: Plates, Viscoelastic properties, Longitudinal vibration, Flexural vibration

The equations of incompressible linear viscoelasticity are averaged over the thickness of a thin plate. The basic equations governing the extensional and flexural motion of the plate are obtained when displacements are assumed to be linear across the thickness of the plate. A dispersion relation governing the propagation of flexural waves is obtained which incorporates characterizing parameters of the material. Numerical results are presented for the decay of waves in a semi-infinite plate which is excited harmonically at one boundary. Results show how characterizing parameters affect the decay of waves.

86-116
Transient Waves in Inhomogeneous Isotropic Elastic Plates
H. Cohen, R.S.D. Thomas
Univ. of Manitoba, Winnipeg, Manitoba, Canada
Acta Mech., 53 (3-4), pp 141-161 (Nov 1984) 9 refs

KEY WORDS: Plates, Wave propagation

This paper deals with the problem of transient wave propagation in isotropic inhomogeneous elastic Cosserat plates of uniform thickness by the method of singular wave curves. The transport equations governing the growth-decay behavior of all extensional and bending wave modes are explicitly integrated to provide a common general formula involving the material parameters and wave geometry.

86-117
Experimental Investigation into the Dynamic Response of a Stiffened Flat Plate Loaded Impulsively by an Underwater Shockwave
R.R. Rentz
Naval Postgraduate School, Monterey, CA
173 pp (June 1984) AD-A151 321/7/GAR

KEY WORDS: Plates, Underwater explosions, Shock waves, Experimental data

The experiment conducted is in support of a broad-based study of underwater shock wave phenomena and the effects they have on ship's hull lethality. An air-backed flat plate with externally machined rectangular stiffeners and a clamped boundary condition was subjected to a shock wave loading generated by an eight pound TNT charge detonated underwater. The plate was instrumented to measure transient strains. The test structure acceleration and free field pressures were also measured. Preshot and postshot calculations were performed using the finite central difference computer code, EPSA.

86-118
Design of Shear Deformable Antisymmetric Angle-Ply Laminates to Maximize the Fundamental Frequency and Frequency Separation
S. Adali
National Res. Inst. for Mathematical Sciences, Pretoria, South Africa
Rept. No. CSIR-TWISK-333, 38 pp (Dec 1983) PB85-152197/GAR

KEY WORDS: Plates, Layered materials, Natural frequencies, Optimization, Transverse shear deformation effects

An antisymmetrically laminated angle-ply plate is optimized with the objectives of maximizing the fundamental eigenfrequency and the distance between two consecutive natural frequencies. A penalty function method is employed to maximize the fundamental frequency, subject to lower bound constraints on higher order frequencies. Numerical results are presented for laminates constructed of high modulus fiber reinforced materials, and the effects of various problem parameters on the efficiency of the designs are investigated.

86-119
Field Equation for the Transverse Motion of a Two-Layered Plate
B.Q. Vu
Naval Ocean Systems Ctr., San Diego, CA
J. Sound Vib., 99 (2), pp 267-273 (Mar 22, 1985) 1 fig, 8 refs

KEY WORDS: Plates, Layered materials, Flexural vibration, Transverse shear deformation effects, Rotatory inertia effects

An approximate theory is developed for the transverse motion of a two-layered plate. The two layers are assumed to be elastic, isotropic, homogeneous and welded to each other. A single equation of transverse motion is derived that predicts the first four antisymmetric modes and is applicable to practical problems. Phase velocities of these modes are numerically analyzed for a plate consisting of a copper layer and a steel layer.

86-120
Variable-Thickness Sandwich Plates: Beam-Like Bending and Vibration of Plates Symmetric About a Middle Surface
C. Libove
Syracuse Univ., Syracuse, NY
Rept. No. MAE-5471-1, NSF/CEE-84049, 120 pp (Jan 1984) PB85-180289/GAR

KEY WORDS: Plates, Sandwich structures, Variable cross section, Flexural vibration, Harmonic response

A theory is presented for the beam-like bending and harmonic vibration of linearly elastic sandwich plates that have thickness variation in one direction (the direction of bending) and are symmetric about a middle surface.

86-121
Vibration Characteristics of Graphite-Epoxy Composite Plates
S.C. Yen, F.M. Cunningham
Southern Illinois University, Carbondale, IL
Experimental Mechanics, Proc. of 1985 SEM Spring Conf., June 9-14, 1985, Las Vegas, NV, pp 60-67, 3 figs, 4 tables, 17 refs

KEY WORDS: Plates, Composite structures, Mode shapes, Natural frequencies, Experimental data

The analytical and experimental vibration characteristics of two graphite/epoxy composite plates is presented. The vibration mode shape of composite plates is found to be quite different from that of isotropic plates. The vibration mode shape of composite plates is found to be antisymmetrical with respect to any axis through the centroid of the plate. Mode shapes are found to occur in a systematic manner and are dependent upon the stiffness of composite plate in a particular direction.

86-122
Modeling of Interlaminar Delamination Using a Finite Element Method
C.A. Ross, L.E. Malvern, E.L. Jerome
Univ. of Florida
Experimental Mechanics, Proc. of 1985 SEM Spring Conf., June 9-14, 1985, Las Vegas, NV, pp 360-368, 7 figs, 1 table, 10 refs

KEY WORDS: Plates, Layered materials, Impact response

Two finite element computer codes have been utilized to model interlaminar delaminations in glass/epoxy, graphite/epoxy and Kevlar 49/epoxy

plates when subjected to a nonperforating central impact. Delamination is assumed to occur when the interlaminar shear strength is exceeded, and interface elements are used to allow slipping of the interlaminar planes.

86-123

Dynamic Stability of Unsymmetrically Laminated Rectangular Plates

V. Birman
Univ. of New Orleans, New Orleans, LA
Mech. Res. Comm., 12 (2), pp 81-86 (Mar/Apr 1985) 1 fig, 1 table, 11 refs

KEY WORDS: Rectangular plates, Layered materials, Dynamic stability

Numerous investigations have considered the vibration and buckling of unsymmetrically laminated composite plates. A simple criterion is presented for the effect of unsymmetrical lamination on the distribution of the instability regions drawn in the axes nondimensional excitation frequency-nondimensional amplitude of external pulsating load. In the case of large aspect ratio plates unsymmetrical lamination is shown to shift these regions to smaller excitation frequencies.

86-124

Vibrations of a Polygonal Plate Having Orthogonal Straight Edges by an Extended Rayleigh-Ritz Method

H. Yamaguchi
Tohoku Univ., Sendai, Japan
J. Sound Vib., 98 (3), pp 313-324 (Feb 8, 1985) 8 figs, 3 tables, 5 refs

KEY WORDS: Rectangular plates, Rayleigh-Ritz method

An extended Rayleigh-Ritz method is presented for solving vibration problems of a polygonal plate having orthogonal straight edges. The polygonal plate is considered as an assemblage of several rectangular plates. By minimizing the energy functional corresponding to the assumed displacement function, the dynamic stiffness matrix of the element rectangular plate, which is similar to that obtained in the finite element method, is derived. The dynamic stiffness matrix of the whole system is obtained by summing up those of the element rectangular plates. Numerical results are presented for the natural frequencies and mode shapes of cantilever L-shaped and T-shaped plates.

86-125

Effect of Thermal Gradient on Frequencies of an Orthotropic Rectangular Plate Whose Thickness Varies in Two Directions

J.S. Tomar, A.K. Gupta
Univ. of Roorkee, Roorkee 247667, India
J. Sound Vib., 98 (2), pp 257-262 (Jan 22, 1985) 2 figs, 10 refs

KEY WORDS: Rectangular plates, Variable cross section, Temperature effects, Natural frequencies

A simple model is presented for the use of research workers in space technology, mechanical sciences and nuclear energy where certain components of structures must operate under elevated temperatures. The effect of a constant thermal gradient on the free vibrations of an orthotropic rectangular plate whose thickness varies linearly in two directions is considered. An approximate but quite convenient frequency equation is derived by using Rayleigh-Ritz techniques with a two-term deflection function.

86-126

Numerical Vibration Analysis of Plate Structures by Newmark's Method

N. Nakahira, Y. Natsuaki, K. Ozawa, M. Naruoka
Katayama Iron Works Ltd., Minamiokajima 6-2-21, Taisho-ku, Osaka, Japan
J. Sound Vib., 99 (2), pp 183-198 (Mar 22, 1985) 7 figs, 2 tables, 13 refs

KEY WORDS: Rectangular plates, Variable cross section, Box beams, Newmark method

The free vibration of plate structures is studied using Newmark's numerical method. Simplicity and usability of the method for design use is demonstrated in several numerical examples. Accuracy of the results is verified by comparison with other numerical methods.

86-127

A Finite Element Method for Nonlinear Forced Vibrations of Rectangular Plates

C. Mei, K. Decha-Umphai
Old Dominion Univ., Norfolk, VA
AIAA J., 23 (7), pp 1104-1110 (July 1985) 5 figs, 4 tables, 26 refs

KEY WORDS: Rectangular plates, Harmonic excitation, Finite element technique

The finite element method has been extended to determine the response of large-amplitude forced vibrations of thin plates. A harmonic force matrix of a rectangular element under uniform harmonic excitation is developed for nonlinear forced vibration analysis. In-plane deformation and inertia are both considered in the formulation. Results obtained are compared with simple elliptic response, perturbation, and other approximation solutions.

86-128
Free Vibrations of a Simply Supported, Rectangular Plate: An Exact Elasticity Solution
M. Levinson
Univ. of Maine at Orono, Orono, ME
J. Sound Vib., 98 (2), pp 289-298 (Jan 22, 1985) 2 tables, 16 refs

KEY WORDS: Rectangular plates, Elastodynamic response

An exact, three-dimensional solution for the free vibrations of simply supported, rectangular plates of arbitrary thickness within the linear theory of elastodynamics is presented. The solution satisfies all of the boundary conditions of the problem in a pointwise manner. It is found that there are two types of modes of oscillation possible which are consistent with the kinematic assumptions made to find the semi-inverse solution. Some numerical results are given which indicate that the predictions of Mindlin plates are uncannily good approximations to the flexural frequencies given by the present, three-dimensional analysis even for very thick plates.

86-129
Hybrid Stress Analysis of Vibrating Plates Using Holographic Interferometry and Finite Elements
M. Engelstad, D. Chambless, W. Swinson, J. Turner
Auburn Univ., Auburn, AL
Experimental Mechanics, Proc. of 1985 SEM Spring Conf., June 9-14, 1985, Las Vegas, NV, pp 541-547, 11 figs, 7 refs

KEY WORDS: Rectangular plates, Cantilever plates, Holographic techniques, Interferometric techniques, Finite element technique

A hybrid-stress analysis technique involving the mating of time-average holographic interferometric displacement data with static finite element analysis resulting in an efficient stress solution to a dynamic problem was investigated. The model studied was a thin rectangular cantilever plate. Real-time holography was used to locate natural vibrating modes of the plate. The experimental data was smoothed to remove experimental scatter using a spline-like finite element procedure in one and two dimensions. The first and fourth modes were investigated and compared to a NASTRAN dynamic solution and to Timoshenko's theoretical solution.

86-130
Random Vibration of a Prestressed, Orthotropic, Thick Rectangular Plate on a Generalized Foundation
S. Chonan
Tohoku Univ., Sendai, Japan
J. Acoust. Soc. Amer., 78 (2), pp 598-604 (Aug 1985) 8 figs, 18 refs

KEY WORDS: Rectangular plates, Elastic foundations, Rotatory inertia effects, Transverse shear deformation effects, Random excitation

The random vibration of a simply supported, prestressed, orthotropic rectangular plate resting on a generalized elastic foundation is studied. The plate is subjected to random forces that are correlated in time, while uncorrelated in space. The problem is studied on the basis of a thick plate theory which takes into account the effect of the second-order increments of the normal stresses in plate, as well as the effect of the rotatory inertia and shear deformations. Results are compared with those from the classical thin plate theory.

86-131
Modal Testing of Circular Plates with Partial Viscoelastic Damping Treatments
K.K. Stevens, J.B. Lopes
Florida Atlantic Univ., Boca Raton, FL
Experimental Mechanics, Proc. of 1985 SEM Spring Conf., June 9-14, 1985, Las Vegas, NV, pp 79-86, 13 figs, 3 tables, 21 refs

KEY WORDS: Circular plates, Viscoelastic damping, Experimental modal analysis, Natural frequencies

Application of modal testing techniques to determine the modal parameters and mode shapes of an edge-fixed circular plate with a free-layer

viscoelastic damping treatment extending over a portion of the surface is described. The test specimen and test procedures are discussed, and experimentally-determined values of the system natural frequencies and loss factors for varying degrees of damping treatment are presented.

86-132
Forced Vibration of the Two-Layer Piezoceramic and Metal Composite Thin Circular Plate with Different Diameter for Each Layer
Mu Ting-rong
Acta Acustica, 9 (5), pp 298-310 (1984) CSTA No. 534-84.38

KEY WORDS: Circular plates, Composite structures

The forced vibrations of a two-layer piezoceramic and metal composite thin circular plate with different diameters, excited with the voltage or uniform pressure, are analyzed. Exact solutions and equations of series and parallel resonance frequencies for simply supported and edge clamped are obtained. The approximate solution forced vibrations, excited with voltage, and the equation of series resonance frequency for the simply supported are given by Rayleigh-Ritz method. The effect of the elastic and inertia coupling on the resonance frequency is discussed.

SHELLS

86-133
Nonlinear Dynamic Analysis with a 48 D.O.F. Curved Thin Shell Element
S. Saigal, T.Y. Yang
Purdue Univ., West Lafayette, IN
Intl. J. Numer. Methods Engrg., 21 (6), pp 1115-1128 (June 1985) 9 figs, 3 tables, 32 refs

KEY WORDS: Shells, Multi degree of freedom systems, Nonlinear theories

Developments of an existing 48 degrees-of-freedom curved, quadrilateral, thin shell element, for materially and geometrically nonlinear static analysis of shell structures, are extended for the study of dynamic responses of nonlinear shells. The variable-order polynomial representations of the shell surface and the non-axisymmetric definition of the shell boundaries allow the study of the dynamic behavior of a class of shell structures more general than those treated by using flat plate elements and elements with assumptions of axisymmetry. The equations of motion are based on a Lagrangian frame of reference. A combination of step-by-step and iterative procedures is used for the solution of nonlinear equations.

86-134
Solution Method for Nonlinear Dynamic Analysis of Shell Structures
K.J. Bathe
Massachusetts Inst. of Tech., Cambridge, MA
Rept. No. BRL-CR-535, SBI-AD-F300 554, 57 pp (Oct 1984) AD-A149 846/8/GAR

KEY WORDS: Shells, Nonlinear theories

A new four-node (non-flat) general quadrilateral shell element for geometric and material static and dynamic nonlinear analysis is presented. The element is formulated using three-dimensional continuum mechanics theory and it is applicable to the analysis of thin and thick shells. The formulation of the element and the solutions to various test and demonstrative example problems are presented and discussed.

86-135
Dynamic Response of a Submerged Prolate Spheroidal Shell to a Longitudinal Shock Wave
J.C. Wawa, F.L. Dimaggio
General Motors Research Labs., Warren, MI
Computers Struc., 20 (6), pp 975-989 (1985) 16 figs, 20 refs

KEY WORDS: Shells, Submerged structures, Shock response, Doubly asymptotic approximation, Plane wave approximation

The dynamic response of a submerged prolate spheroidal shell to a plane rectangular shock wave moving parallel to the major axis is studied. Using a coordinate transformation which converts an infinite acoustic medium into a finite rectangular one, an exact solution is obtained by finite differences. Approximate structural responses, based on both plane wave and doubly asymptotic fluid behavior on the wet surface, are then compared with the exact results.

86-136

Harmonic Response of Cylindrical and Toroidal Shells to an Internal Acoustic Field. Part I: Theory

M. El-Raheb, P. Wagner
California Inst. of Tech., Pasadena, CA

J. Acoust. Soc. Amer., 78 (2), pp 738-746 (Aug 1985) 6 figs, 2 tables, 10 refs

KEY WORDS: Cylindrical shells, Toroidal shells, Acoustic excitation, Internal forces

The coupled elastic and acoustic response of a system of cylindrical and toroidal shells enclosing an acoustic medium is presented. The theory to model the elastodynamics of cylindrical and toroidal segments of shell is developed. The elastic simulation is based on transfer matrices while the acoustic simulation adapts a Green's function and curved surface elements. Equilibrium of the acoustic pressure and internal reactions of the shell and compatibility between the acoustic and elastic accelerations at the shell-fluid interface determine the coupled response.

86-137

Harmonic Response of Cylindrical and Toroidal Shells to an Internal Acoustic Field. Part II: Results

M. El-Raheb, P. Wagner
California Inst. of Tech., Pasadena, CA

J. Acoust. Soc. Amer., 78 (2), pp 747-757 (Aug 1985) 9 figs, 2 tables, 3 refs

KEY WORDS: Cylindrical shells, Toroidal shells, Acoustic excitation, Internal forces, Harmonic response

General systems of cylindrical and toroidal shells enclosing an acoustic medium are studied by their response to acoustic excitation by a plane wave with harmonic time dependence. The analysis demonstrates the inadequacy of beam theory to model the response of short and thin shell configurations at frequencies above the fundamental elastic resonance.

86-138

Nonlinear Faraday Resonance

J.W. Miles
Univ. of California, San Diego, La Jolla, CA

J. Fluid Mechanics, 146, pp 285-302 (1984)

KEY WORDS: Cylindrical shells, Fluid-filled containers, Internal resonance

A cylinder containing liquid with a free surface is subjected to a vertical oscillation of amplitude and frequency. A Lagrangian formulation, which includes terms of second and fourth order in the primary mode and second order in the secondary modes, together with the method of averaging, leads to a Hamiltonian system for the slowly varying amplitudes of the primary mode. The fixed points and phase-plane trajectories and their perturbations due to linear damping are determined. Explicit results are given for the dominant axisymmetric and antisymmetric modes in a circular cylinder.

86-139

Tank Damage During the May 1983 Coalinga Earthquake

G.C. Manos, R.W. Clough
Univ. of Thessaloniki, Greece

Earthquake Engrg. Struc. Dynam., 13 (4), pp 449-466 (July/Aug 1985) 24 figs, 3 tables, 23 refs

KEY WORDS: Tanks (containers), Earthquake damage, Cylindrical shells, Sloshing

The Coalinga earthquake of 2 May 1983 caused intense ground shaking throughout the epicentral region. Unanchored cylindrical ground supported tanks located at six sites within this oil producing area were damaged. An estimate is made of the intensity of ground motion at each of the tank sites, based on strong motion records made during the main shock and the strongest aftershock. Response parameters specified by current codes are correlated with the damages observed at each tank site.

86-140

Resonance Sound Transmission into Arbitrarily Loaded Submerged Cylindrical Shells

G.C. Gaunaurd, J. Barlow
Naval Surface Weapons Ctr., White Oak, Silver Spring, MD

J. Acoust. Soc. Amer., 78 (1), pp 223-233 (July 1985) 9 figs, 19 refs

KEY WORDS: Cylindrical shells, Submerged structures, Sound transmission

The fundamental exact analytical and computational model required to study the transmission of incident plane sound waves into submerged elastic cylindrical shells subjected to arbitrary

forcing functions on their outer surface is developed. The superposition principle in this linear problem to separate the contributions to the internally transmitted field caused by the incident wave from that of the surface excitation. The investigation demonstrates the filtering behavior of the shell in the frequency domain and its focusing action in space.

86-141
Dynamic Analysis of Prismatic Structures Surrounded by an Infinite Fluid Medium
Y.K. Cheung, Cao Zhi-Yuan, S.Y. Wu
Univ. of Hong Kong, Hong Kong
Earthquake Engrg. Struc. Dynam., 13 (3), pp 351-360 (May/June 1985) 5 figs, 8 tables, 6 refs

KEY WORDS: Shells, Prismatic bodies, Submerged structures, Off-shore structures, Fluid-structure interaction

For coupled vibration analyses of prismatic shell structures immersed in an infinite fluid medium, a composite element consisting of a semi-analytical infinite fluid element and a cylindrical shell strip element is proposed. The behavior in the infinite direction can be accurately modeled with minimum effort and great savings in computational cost is achieved using this element. This method may be used to analyze the dynamic behavior of prismatic shell structures with arbitrary *cross-sections in offshore engineering.*

86-142
A Perturbation Method in Elastohydrodynamic Lubrication of Cylindrical Surfaces
A. Baroncelli, R. Bassani
Universita degli Studi di Pisa, Italy
Meccanica, 20 (1), pp 79-84 (Mar 1985) 6 figs, 11 refs

KEY WORDS: Cylindrical shells, Elastohydrodynamic properties, Perturbation theory

The typical relations of elastohydrodynamics are linearized through geometrical considerations and a single integro-differential equation, where the pressure is the unknown quantity, is found. A perturbation method is used for the solution, and, in the assumption of an incompressible and isoviscous fluid, an explicit expression of the pressure gradient and, consequently, of the total load and the film thickness is obtained when displacements are not high.

PIPES AND TUBES

86-143
Dynamics of a Pipe Aspirating Fluid Such as Might be Used in Ocean Mining
M.P. Paidoussis, T.P. Luu
McGill Univ., Montreal, Quebec, Canada
J. Energy Resources Tech., Trans. ASME, 107 (2), pp 250-255 (June 1985) 3 figs, 2 tables, 22 refs

KEY WORDS: Pipes, Submerged structures, Off-shore structures, Mining equipment

An investigation into the dynamics and stability of a long, vertically disposed, cantilevered pipe, submerged in and aspirating fluid from the free lower end, and conveying it upwards to the supported upper end is presented. The pipe has a large mass attached to its free end. The arrangement represents an idealization of an ocean mining system.

86-144
Application of the Transfer Matrix Method to Non-Conservative Systems Involving Fluid Flow in Curved Pipes
C. Dupuis, J. Rousselet
Ecole Polytechnique, Campus de l'Universite de Montreal, Montreal, Quebec, Canada
J. Sound Vib., 98 (3), pp 415-429 (Feb 8, 1985) 4 figs, 1 table, 31 refs

KEY WORDS: Pipes, Fluid-filled containers, Fluid-induced excitation, Transfer matrix method

The application of the transfer matrix method to problems of fluid flow in planar curved pipes is presented. A presentation is given on dealing with the stability of non-conservative problems when using the dynamic method. Account is taken of the effect of the initial state of stress on the dynamic behavior of the pipe.

86-145
Waves in Fluid Filled Tubes: Theory and Experiment
T.B. Moodie, D.W. Barclay, S.E. Greenwald, D.L. Newman
Univ. of Alberta, Edmonton, Canada
Acta Mech., 54 (1-2), pp 107-119 (Dec 1984) 5 figs, 7 refs

KEY WORDS: Tubes, Fluid-filled containers, Viscoelastic properties

The problem of pulse propagation in fluid filled distensible tubes is considered. Numerical results obtained from the solution to a boundary value problem are compared with experimental results. The results emphasize that pulse propagation in fluid filled distensible tubes can accurately be modeled by a linear theory and that nonlinear effects are minimal. The broadening and attenuation are a result of the viscoelastic nature of the wall material.

86-146
Research on Wave Phenomena in Hydraulic Lines (11th Report, Harmonic Waves in Coaxial Double Pipes)
S. Washio, T. Konishi
Okayama Univ., Okayama City, Japan
Bull. JSME, 28 (241), pp 1409-1415 (July 1985) 10 figs, 9 refs

KEY WORDS: Pipelines, Concentric structures, Wave propagation, Hydraulic equipment

One of the new elements employed to control and suppress wave transmission in hydraulic lines, the coaxial double pipe, is investigated. The equation for a viscous wave flow between two cylindrical walls of different radii with the same axis is solved. For the case of periodical waves, the complicated solutions including many-valued complex Bessel functions of the 2nd kind are rigorously computed and conveniently approximated.

86-147
Hydrodynamic Forces on Multitube Production Risers Exposed to Currents and Waves
Z. Demirbilek, T. Halvorsen
Conoco, Inc., Ponca City, OK
J. Energy Resources Tech., Trans. ASME, 107 (2), pp 226-234 (June 1985) 4 figs, 5 tables, 10 refs

KEY WORDS: Tube arrays, Marine risers, Cylinders, Hydrodynamic excitation, Measurement techniques

The experimental results of a joint industry riser test program are presented. Over a five-year period, an extensive experimental investigation of hydrodynamic loads acting on various production risers was carried out. The program included the laboratory testing of many multitube riser configurations as well as a single cylinder. Several major oil companies sponsored the project. The tests were made with rather large-scale models. The primary objective of this investigation was to establish an accurate measurement of the hydrodynamic forces on bundle-type risers.

DUCTS

86-148
Modal Filters in Rectangular Ducts
A. Cabelli, I.C. Shepherd, R.F. La Fontaine
Commonwealth Scientific and Industrial Research Organization, Melbourne, Australia
J. Sound Vib., 99 (2), pp 285-292 (Mar 22, 1985) 4 figs, 7 refs

KEY WORDS: Ducts, Modal filters

Disruption to the propagation of higher order modes in a duct can be achieved by locating splitter plates at appropriate positions inside the duct. Since certain modes are reflected or attenuated, this constitutes a modal filter. Characteristics of this geometry with rigid splitters and with finite impedance splitters are discussed for propagating acoustic modes.

BUILDING COMPONENTS

86-149
Inelastic Analysis of R/C Coupled Shear Walls
M. Keshavarzian, W.C. Schnobrich
Univ. of Illinois, Urbana, IL
Earthquake Engrg. Struc. Dynam., 13 (4), pp 427-448 (July/Aug 1985) 18 figs, 18 refs

KEY WORDS: Walls, Reinforced concrete, Seismic excitation

A method of analysis capable of calculating the response of an R/C coupled shear wall structure subjected to strong earthquake motion without major complications existing in the method itself is presented. The relative simplicity is achieved while retaining reasonable reliability in the computed response. The effects of moment-axial force interaction in the wall members on

the computed overall responses of the coupled shear wall structures and on the behavior of each individual wall are discussed.

86-150
Seismic Response of Composite Masonry in New and Existing Structures
S.C. Anand
Clemson Univ., SC
Rept. No. REPT-30S-84, NSF/84050, 44 pp (Nov 1984) PB85-166643/GAR

KEY WORDS: Walls, Masonry, Seismic response

This report summarizes the results of experimental and analytical research on the behavior of composite masonry walls, subjected to inplane loads on only one wythe. Most of the effort in this research has been focused on the determination of shear stresses in the collar joint, both analytically and experimentally, due to the vertically applied loads on the block wythe. Finite element models have also been developed to predict these shear stresses due to creep in composite masonry, and due to shrinkage and moisture expansion.

86-151
Seismic Design of Gravity Retaining Walls
R.V. Whitman, S. Liao
Massachusetts Inst. of Tech., Cambridge, MA
Rept. No. WES/MP/GL-85-1, 156 pp (Jan 1985) AD-A152 325/7/GAR

KEY WORDS: Retaining walls, Seismic design

The report discusses the seismic design of gravity walls retaining granular backfill without pore water. The general features of behavior are illustrated by field experiences, results from laboratory model tests and from theoretical analyses. Both the conventional method of design and the Richards-Elms method, based upon an analogy to a sliding block, are reviewed. A probabilistic method for predicting seismically induced displacements of walls and an improved version of the Richards-Elms method of design is developed.

86-152
Analytical and Experimental Studies of Suspended Floor Structures with Coulomb Friction Elements
J.A. Malthan, S.F. Masri, O.T. Hata
Agbabian Associates, El Segundo, CA
Rept. No. AA-R-8121-5617, NSF/CEE-84047, 188 pp (Nov 30, 1984) PB85-168870/GAR

KEY WORDS: Floors, Suspended structures, Coulomb friction, Seismic response

This report introduces the problem of studying suspended floor structures, especially with regard to the more general mathematical models that may be used to investigate their seismic response when taken as a system of structural elements. Past analytical studies are summarized. Analytical studies were conducted by means of a simplified nonlinear multidegree-of-freedom system consisting of two bodies interconnected by a Coulomb friction element. These studies were aimed at developing guidelines for performing reliable finite-element computer analysis of the transient dynamic response of structures possessing such highly nonlinear characteristics.

86-153
On the Natural Freqeuncies of Infilled Frames
V. Thiruvengadam
Central Public Works Dept., Government of India, New Delhi-11, India
Earthquake Engrg. Struc. Dynam., 13 (3), pp 401-419 (May/June 1985) 12 figs, 3 tables, 22 refs

KEY WORDS: Frames, Composite structures, Natural frequencies, Mode shapes, Seismic response

Three approximate models are considered for the evaluation of the first few natural frequencies and associated mode shapes of infilled frames, a commonly occurring composite structural system formed by the combination of plane frames and filler walls. The reasonableness of the models is checked with the available experimental results and with the corresponding finite element solutions. The effect of frame-infill separation in reducing the fundamental frequency is investigated and an empirical relation is presented.

ELECTRIC COMPONENTS

ELECTRONIC COMPONENTS

86-154
Vibration Reduction of Magnetic Disk Drive Mechanism (1st Rept.: Vibration Reduction of Rotary Actuator Mechanism)
H. Ohta, J. Naruse, T. Hirata
Hitachi Mech. Engrg. Res. Lab., Ibaraki 300, Japan
Bull. JSME, 28 (241), pp 1489-1496 (July 1985) 20 figs, 3 refs

KEY WORDS: Computer storage devices, Vibration control

A magnetic disk drive is excited by an actuator force and a disk driving force. It is shown that vibration reduction results when the actuator force is applied to the rotary access mechanism. A vibration analysis utilizing a building block approach confirms that the carriage assembly structure contributes largely to the vibration characteristics of the access mechanism. The relation between the structural stiffness of each element and its vibration characteristics is clarified.

DYNAMIC ENVIRONMENT

ACOUSTIC EXCITATION

86-155
Reduction of Instrumentation Noise (Gerauschminderung in der Geratetechnik)
G. Herklotz, W. Krause, D. Schick, J. Thummler
Technische Universitat Dresden, German Dem. Rep.
Feingeratetechnik, 34 (3), pp 132-135 (1985) 3 figs, 3 tables (In German)

KEY WORDS: Noise reduction, Instrumentation, Mechanical admittance, Mechanical impedance, Coulomb friction

The nature of structure-born noise, which is much more complicated than the noise propagated in air, should be understood before taking any measures to reduce it. The concepts of impedance, admittance, and friction damping are discussed and the reduction of structure-borne noise by controlling its propagation is described.

86-156
Spherical Acoustic Resonator: Effects of Shell Motion
J.B. Mehl
Univ. of Delaware, Newark, DE
J. Acoust. Soc. Amer., 78 (2), pp 782-788 (Aug 1985) 2 figs, 26 refs

KEY WORDS: Acoustic resonators, Spherical shells, Fluid-filled containers

The exact theory of classical elasticity is used to calculate the response of an isotropic spherical shell to an acoustic mode of the fluid enclosed by the shell. The results are used to calculate the shifts of the acoustic resonance frequencies from the values which correspond to perfectly rigid shell walls. Numerical calculations of the shell resonance frequencies are presented for a wide range of shell thicknesses.

86-157
Twenty-Five Sound Propagation Tests on the Continental Shelf Between Long Island, New York and Cape Canaveral, Florida
J.B. Hersey, C.B. Officer, L. Baxter, L.C. Davis
Science Applications International Corp., McLean, VA
Rept. No. SAIC-84/1424, 95 pp (Nov 1984) AD-A149 869/O/GAR

KEY WORDS: Sound waves, Wave propagation, Underwater sound, Experimental data

Sound propagation measurements were made combined with seismic refraction profiles, bathythermograph profiles, and continuous echo soundings over more than 42 different tracks that lie partly or wholly within the 200-meter depth contour of the U.S. east coast continental shelf between latitude 26 N and 40 N. Spectrum levels of propagation loss (PL) have been computed for octave frequency bands 50 to 100 Hz, 200 to 400 Hz, 800 to 1600 Hz, and 2400 to 4800 Hz.

86-158
Nearfield Acoustical Holography Using an Underwater, Automated Scanner
E.G. Williams, H.D. Dardy, R.G. Fink
Naval Res. Lab., Washington, DC
J. Acoust. Soc. Amer., 78 (2), pp 789-798 (Aug 1985) 7 figs, 1 table, 14 refs

KEY WORDS: Underwater sound, Acoustic holography

A computer-controlled, three-axis Cartesian scanning facility, constructed in a large water tank to provide accurate preprogrammed contouring with hydrophone probes, is described. As the scanner moves on the preprogrammed contours, usually located very close to a radiating object, the pressure field is sampled at discrete points until a two-dimensional pressure map is obtained. This pressure map is essentially a hologram containing amplitude and phase information which can be processed with a computer using a technique called nearfield acoustical holography. This processing provides the pressure, vector velocity, and vector intensity anywhere in the space from the surface of the source to the farfield.

86-159
Modeling of Reciprocity in the Time Domain Using the Parabolic Equation Method
Nghiem-Phu Lan, F. Tappert
Daubin Systems Corp., Miami, FL
J. Acoust. Soc. Amer., 78 (1), pp 164-171 (July 1985) 3 figs, 13 refs

KEY WORDS: Underwater sound, Sound transmission loss, Time domain method

Transmission loss in the time domain is carefully defined, and it is shown to be reciprocal on the basis of the reduced wave equation in fully range-dependent and lossy oceanic environments when currents and other reciprocity-breaking effects are absent. Under the same conditions, it is shown theoretically that time-domain transmission loss as computed by the two-dimensional parabolic equation (PE) method is reciprocal. In a range-dependent bottom-limited ocean, the time-domain transmission loss has been numerically computed and its reciprocal has been independently computed using the parabolic equation method and split-step Fourier algorithm.

86-160
Implications of Multipath Propagation for Two-Frequency Coherence Measurements
T.G. Birdsall, F. Khan
Univ. of Michigan, Ann Arbor, MI
J. Acoust. Soc. Amer., 78 (1), pp 105-111 (July 1985) 5 figs, 2 tables, 2 refs

KEY WORDS: Underwater sound, Sound propagation

The underwater acoustic medium is modeled as a deterministic multipath channel. A moving source transmits two pure sinusoidal signals. The receiver separates the signals by filtering, and then demodulates them. Two-frequency coherence is defined as the normalized cross correlation of the two demodulates. A new measurement technique is suggested whereby it is shown that the coherent bandwidth for a channel with only deterministic multipaths is essentially unlimited and paths of significant gain may be resolved by using long measurement times. A lower bound on measurement time for path resolution is obtained.

86-161
A Technique for the Measurement of Extinction Cross Section
B.V. Smith, M.G. Ertugrul
Univ. of Birmingham, Birmingham, UK
J. Sound Vib., 98 (2), pp 275-288 (Jan 22, 1985) 6 figs, 4 tables, 15 refs

KEY WORDS: Underwater sound, Sound waves, Wave scattering

A method is described for the measurement of the acoustic extinction cross section of an object underwater. Use is made of the forward-scattering theorem which directly relates the extinction cross section of an object to the quadrature component of the scattered field in the forward direction. In the measurement technique the forward-scattered field is separated from the incident field by a simple cancellation process. The extinction cross section of a number of spheres and discs have been measured and the results are shown to be in good agreement with theoretical predictions.

86-162
Scattering of Low-Frequency Acoustic Waves by Babbled Membranes and Plates
D.S. Ahluwalia, G.A. Kriegsmann, E.L. Reiss
Northwestern Univ., Evanston, IL
J. Acoust. Soc. Amer., 78 (2), pp 682-687 (Aug 1985) 1 table, 8 refs

KEY WORDS: Underwater sound, Sound waves, Wave scattering, Plates, Membranes

The method of matched asymptotic expansions is used to study the scattering of plane, monochromatic, acoustic waves from baffled flexible surfaces. The method is applied to obtain the fields scattered by rectangular membranes and plates. It is found that plates are more efficient scatterers than similar membranes if the plates are sufficiently thin.

86-163
Ray Theory Modeling Applied to Low-Frequency Acoustic Interaction with Horizontally Stratified Ocean Bottoms
M.W. Lawrence
Woods Hole Oceanographic Instn., Woods Hole, MA
J. Acoust. Soc. Amer., 78 (2), pp 649-658 (Aug 1985) 13 figs, 25 refs

KEY WORDS: Underwater sound, Wave propagation

Ray theory is applied to the interaction of acoustic waves with a horizontally stratified ocean bottom. The model applies to a fluid bottom with absorption. Local ray calculations are used throughout. At discontinuous interfaces, rays are allowed to split and each resulting ray is then followed. Corrections that are found to be essential for good agreement with full-wave treatments are caustic boundary corrections and beam displacement corrections.

86-164
Parabolic Equation Modeling of the Effects of Ocean Currents on Sound Transmission and Reciprocity in the Time Domain
Lan Nghiem-Phu, F. Tappert
Daubin Systems Corp., Miami, FL
J. Acoust. Soc. Amer., 78 (2), pp 642-648 (Aug 1985) 3 figs, 10 refs

KEY WORDS: Underwater sound, Sound transmission loss, Time domain method

Transmission loss in the time domain is examined in the presence of ocean currents using the parabolic equation method. The transmission loss functions in the time domain are computed from solutions of the parabolic equation obtained by using the split-step Fourier algorithm. Within the context of the parabolic approximation, a nonreciprocal relationship when ocean currents are included is derived theoretically. Current effects on one-way and reciprocal pulse responses are illustrated by means of a numerical example. Approximations are presented together with an efficient technique for assessing the influence of ocean currents on reciprocal transmission between various positions of sources and receivers.

86-165
Geometric Considerations in Determining the Optimum Frequency of Acoustic Propagation in a Shallow Water Waveguide
D.A. Gershfeld, A.I. Eller
Naval Res. Lab., Washington, DC
J. Acoust. Soc. Amer., 78 (2), pp 632-641 (Aug 1985) 11 figs, 1 table, 15 refs

KEY WORDS: Underwater sound, Wave propagation

The effect of various basic physical and environmental parameters that determine the optimum frequency of acoustic propagation in shallow water is investigated through the use of a wave-theoretic analytical model which is computationally simple to evaluate. The model is expressed in two alternative forms, the first consisting of a sum over the allowed normal modes in the duct and the second being the Poisson sum transform of the first. The primary objective of the paper is to demonstrate that the optimum frequency is strongly dependent upon the respective depths and separation distance of the source-receiver pair.

86-166
Low-Frequency Acoustic Response of Shallow Water Ducts
A.I. Eller, D.A. Gershfeld
Naval Ocean Res. and Dev. Activity, NSTL, MS
J. Acoust. Soc. Amer., 78 (2), pp 622-631 (Aug 1985) 15 figs, 2 tables, 20 refs

KEY WORDS: Underwater sound, Wave propagation

The ocean bottom can exert a dominating influence on the propagation of sound in shallow water. Not only does the bottom act to confine the acoustic field as in a duct or waveguide, but in addition the bottom provides the major source of acoustic loss at low frequency. This paper examines the effects on shallow water propagation of two canonical models of bottom structure -- an isovelocity fast sediment whose sound

speed is substantially greater than that of water, and a slow sediment whose sound speed at the interface equals that of water and which has a positive, upward refracting gradient.

86-167
The Dependence of Bottom Backscattering on the Structure of a Layered Scattering Medium
R.J. Wyber
Univ. of Texas at Austin, Austin, TX
J. Acoust. Soc. Amer., 78 (2), pp 665-671 (Aug 1985) 2 figs, 13 refs

KEY WORDS: Underwater sound, Layered materials, Acoustic scattering

This paper develops a model for bottom backscattering which takes account of the structure, of the layering and the characteristics of the measurement system. Parameters are identified which should be measured to allow the backscattering to be predicted for any incident angle and any arbitrary signal and transducer configuration.

86-168
Rather-High-Frequency Sound Scattering by Swimbladdered Fish
K.G. Foote
Inst. of Marine Res., 5011 Bergen, Norway
J. Acoust. Soc. Amer., 78 (2), pp 688-700 (Aug 1985) 7 figs, 4 tables, 67 refs

KEY WORDS: Underwater sound, Acoustic scattering

A new model describes acoustic scattering by swimbladdered fish of lengths from at least 8 to 36 wavelengths. It represents a fish by an ideal pressure-release surface having the exact size and shape as the swimbladder. The backscattering cross section, or target strength, is computed by means of the Kirchhoff approximation. To test the model, predictions of target strengths based on swimbladder morphometries of 15 gadoids of lengths from 31.5 to 44.5 cm are compared with conventional target strength measurements on the same, surface-adapted fish, anesthetized before acoustic measurement, and shock-frozen immediately afterwards. Details are given of the swimbladder morphometry.

86-169
Energy Streamlines of a Sound Source
R.V. Waterhouse, T.W. Yates, D. Feit, Y.N. Liu
David W. Taylor Naval Ship Res. & Dev. Ctr., Bethesda, MD
J. Acoust. Soc. Amer., 78 (2), pp 758-762 (Aug 1985) 8 figs, 8 refs

KEY WORDS: Sound waves, Wave propagation

A method is presented for computing the energy streamlines of a sound source. This enables charts to be plotted showing, as continuous lines, the flow paths of the sound energy from the vibrating surface to the nearfield and beyond. Energy streamlines appear to be a new construct; they have some similarities to the velocity streamlines used in fluid dynamics. Examples of the energy streamlines are given for the point-driven plate in water.

86-170
A Uniform Asymptotic Solution for Nonlinear Surface Acoustic Waves
E.A. David
Indian Inst. of Science, Bangalore - 560012, India
Ind. J. Engrg. Sci., 23 (7), pp 699-708 (1985) 7 figs, 20 refs

KEY WORDS: Sound waves, Asymptotic approximation

A complete investigation of the coupled amplitude theory of nonlinear surface acoustic waves on an isotropic elastic solid, which avoids the limitations encountered in previous theories, is presented. A complete, uniformly valid solution in the interior of the medium is derived. Perspective drawings to study asymptotically the growth-decay cycles the displacement and the velocity profiles, are included.

86-171
Possibilities and Limits of Sound Power Measurements with a Real-Time Intensity Analyzer
A. Stirnemann, U. Bolleter, E.J. Rathe
Sulzer Brothers Limited, Wintethur, Switzerland
J. Sound Vib., 98 (3), pp 403-413 (Feb 8, 1985), 8 figs, 1 table, 11 refs

KEY WORDS: Sound power levels, Acoustic intensity method, Sound measurement

The sound power of a number of test objects was determined from spatially averaged intensity measurements. The results show that the influence of room acoustics is insignificant even for rooms of widely different room constants, if the measuring surfaces are exactly defined and if a good space-averaging technique is used.

86-172

An "Optical" Theorem for Acoustic Scattering by Baffled Flexible Surfaces

G.A. Kriegsmann, A.N. Norris, E.L. Reiss
Northwestern Univ., Evanston, IL
J. Sound Vib., 99 (3), pp 301-307 (Apr 8, 1985), 8 refs

KEY WORDS: Sound waves, Wave scattering, Membranes, Plates

The classical optical theorem for scattering by compact obstacles is a forward scattering theorem; i.e., the total cross section of the obstacle is proportional to the imaginary part of the far field directivity factor evaluated in the forward scattering direction. An analogous theorem is derived for the scattering of acoustic waves by baffled membranes and plates. In this optical theorem the directivity factor is evaluated in the direction of the specularly reflected wave so that it is a reflected scattering theorem.

86-173

Measurement of Acoustic Shielding by a Turbulent Jet

J.C. Yu, D.J. Fratello
NASA Langley Res. Ctr. Hampton, VA
J. Sound Vib., 98 (2), pp 183-212 (Jan 22, 1985), 41 figs, 24 refs

KEY WORDS: Sound waves, Wave attenuation, Turbulence

The acoustic shielding properties of a turbulent jet have been investigated experimentally. The experimental arrangement consisted of an acoustic point source and a turbulent shielding jet. The source and jet parameters investigated include the source frequency, source spectrum, jet velocity, jet heating by simulation and the lateral and longitudinal source positions with respect to the shielding jet. It is found that the maximum sound attenuation provided by the shielding jet depends on the balance between refraction and diffraction.

86-174

A Mathematical Model of Low Amplitude Pulse Combustion Systems Using a Helmholtz Resonator-Type Approach

J.H. Lee, B. Dhar, W. Soedel
Purdue Univ., West Lafayette, IN
J. Sound Vib., 98 (3), pp 379-401 (Feb 8, 1985), 22 figs, 15 refs

KEY WORDS: Helmholtz resonators, Combustion engines, Mathematical models, Pulse combustion devices

Pulse combustion devices consisting of one or two combustion chamber-pulse tube combinations attached to a exhaust decoupling chamber and a long exhaust pipe were modeled using Helmholtz resonator concepts. Comparisons of theory with experiment are presented and questions of operational stability are discussed.

86-175

Scattering of Sound in Industrial Spaces

U.J. Kurze
Muller-BBM GmbH, Munich, Fed. Rep. Germany
J. Sound Vib., 98 (3), pp 349-364 (Feb 8, 1985), 8 figs, 2 tables, 21 refs

KEY WORDS: Sound waves, Wave scattering, Industrial facilities

A rigorous solution is derived for the steady state sound field of a point source in a space randomly filled with absorptive scatterers. With use of approximations for fields in bounded spaced, sound distributions are calculated for shallow industrial work rooms accounting for effects of scattering, specular reflections from floor and ceiling, and shielding by barriers. Theoretical results are compared with data from model and field measurements.

86-176

A Numerical Method for Acoustic Normal Modes for Shear Flows

M.B. Porter, E.L. Reiss
Northwestern Univ., Evanston, IL
J. Sound Vib., 100 (1), pp 91-105 (May 8, 1985), 2 figs, 5 tables, 9 refs

KEY WORDS: Normal modes, Sound waves, Wave propagation, Ducts

The normal modes and their propagation numbers for acoustic propagation in wave guides with flow

are the eigenvectors and eigenvalues of a boundary value problem for a non-standard Sturm-Liouville problem. It is non-standard because it depends nonlinearly on the eigenvalue parameter. A method is presented for the fast numerical solution of this problem. A finite difference method is employed that combines well known numerical techniques and a generalization of the Sturm sequence method to solve the resulting algebraic eigenvalue problem. A modified Richardson extrapolation method is used that dramatically increases the accuracy of the computed eigenvalues. The method is applied to two problems.

86-177
Road Traffic Sound Level Distributions
C.G. Don, I.G. Rees
Chisholm Inst. of Technology, Victoria 3145, Australia
J. Sound Vib., 100 (1), pp 41-53 (May 8, 1985), 10 figs, 2 tables, 10 refs

KEY WORDS: Traffic noise, Sound level meters

A microprocessor-controlled instrument used to form a traffic noise level histogram with a resolution better than 0.1 dB per channel is described. The instrument calculates the mean, standard deviation, skewness and kurtosis of the distribution. The results of over 200 measurement, of 400 s duration, are shown to be in disagreement with predictions based on the commonly assumed Gaussian distribution.

86-178
Fourier Acoustics: An Approach to Acoustic-Field Analysis (Fourier-Akustik: Ein Verfahren zur Schallfeldanalyse)
H. Fleischer, V. Axelrad
Hochschule der Bundeswehr, Munich, Fed. Rep. Germany
Acustica, 57 (2), pp 51-61 (Feb 1985), 7 figs, 20 refs (In German)

KEY WORDS: Sound waves, Wave propagation, Fast fourier transform

The Fourier method is applied to the analysis of acoustic fields. Instead of performing calculations in the space-domain, the analysis is done completely in the spatial Fourier-domain. The determination of the acoustic field belonging to a distribution of acoustic pressure or velocity given on a boundary plane is thus reduced to weighting the Fourier transform via appropriate transfer functions. One of these functions projects pressure from the boundary plane into space, the other converts velocity to pressure. The emphasis is laid on the discussion of the transfer functions and is illustrated by examples.

86-179
Stationary Sound Propagation in Flat Enclosures (Stationare Schallausbreitung in Flachraumen)
H. Kuttruff
Institut f. Technische Akustik, RWTH Aachen
Acustica, 57 (2), pp 62-70 (Feb 1985) 9 figs, 2 tables, 9 refs (In German)

KEY WORDS: Sound waves, Wave propagation, Enclosures

The stationary propagation of sound is investigated in enclosures such as landscaped offices or flat factory rooms. The influence of the sidewalls is neglected.

86-180
The Noise from Normal-Velocity-Profile Coannular Jets
H.K. Tanna, P.J. Morris
Lockheed-Georgia Co., Marietta, GA
J. Sound Vib., 98 (2), pp 213-234 (Jan 22, 1985) 14 figs, 3 tables, 14 refs

KEY WORDS: Jet noise, Turbofan engines, Noise generation

The noise from subsonic coannular jets with normal velocity profiles (to represent typical high-bypass-ratio turbofan engines) is studied experimentally and theoretically. The source alteration effects and the flow-acoustic interaction effects are isolated as far as possible for all jet conditions. In the acoustic experiments, the effects of fan-to-primary velocity ratio and static temperature ratio are quantified explicitly. The coannular jet noise levels are compared directly with the equivalent single jet noise levels for fixed aerodynamic performance of the engine.

86-181
Characterization of Snow by Acoustic Sounding: A Feasibility Study

S.M. Lee, J.C. Rogers
Michigan Technological Univ., Houghton, MI
J. Sound Vib., 99 (2), pp 247-266 (Mar 22, 1985)
12 figs, 6 tables, 32 refs

KEY WORDS: Acoustic properties, Snow

The feasibility of characterizing the structural properties of snow from its acoustic behavior is demonstrated. Snow has characteristics similar to many other acoustically porous media. An in situ experimental procedure, which meets the requirements not to disturb the deposited snow sample on the ground during the experiments, is devised by means of acoustic sounding. Acoustic pulses incident perpendicularly on the snow surface and their return echos can be analyzed by the cepstral technique.

SHOCK EXCITATION

86-182
An Efficient Numerical Algorithm for Transverse Impact Problems
B.V. Sankar, C.T. Sun
Purdue Univ., West Lafayette, IN
Computers Struc., 20 (6), pp 1009-1012 (1985) 4 figs, 9 refs

KEY WORDS: Impact response, Indentation

Transverse impact problems in which the elastic and plastic indentation effects are considered, involve a nonlinear integral equation for the contact force, which, in practice, is usually solved by an iterative scheme with small increments in time. A numerical method is proposed wherein the iterations of the nonlinear problems are separated from the structural response computations. This makes the numerical procedures much simpler and also efficient.

86-183
Estimation of the Dynamic Cavitation Tension of Water by a Shock Tube Method
M.R. Driels
Univ. of Rhode Island, Kingston, RI
J. Sound Vib., 98 (3), pp 365-377 (Feb 8, 1985)
12 figs, 14 refs

KEY WORDS: Submerged structures, Shock waves

A review is conducted into existing work related to the role bulk cavitation plays during the interaction between a submerged structure and an underwater shock wave. This survey, dealing both with the classical works of Temperley and Cushing as well as recently published studies by the writer, is focused on two important variations from the assumptions made in earlier works. One of these variations, the possibility that water has a non-zero cavitation tension, is studied further by developing a theoretical model to predict the fluid dynamics following a free surface reflection.

86-184
High Explosive Testing of a Corrugated Metal Blast Shelter with Membrane Blast Doors
G.P. Zimmerman, C.V. Chester
Oak Ridge National Lab., Oak Ridge, TN
Rept. No. ORNL/TM-9289, 73 pp (Dec 1984)
DE85004109/GAR

KEY WORDS: Blast resistant structures, Doors, Dynamic tests, Nuclear explosion effects

A high-explosive blast test, nicknamed DIRECT COURSE, simulated the blast effects from a one-kiloton nuclear detonation and provided an environment for the testing of selected blast and fallout shelters for their structural integrity. A set of experiments were fielded at the DIRECT COURSE event which were directed toward reducing the cost of blast shelter for small groups of people, such as workers in critical industries (keyworkers). Six items were tested: three scale models of a corrugated metal blast shelter and three full-size blast door closures for such a shelter.

86-185
Tertiary Systems
A.G. Hernried, J.L. Sackman
Univ. of Utah, Salt Lake City, UT
Earthquake Engrg. Struc. Dynam., 13 (4), pp 467-479 (July/Aug 1985) 8 figs, 4 refs

KEY WORDS: Equipment-structure interaction, Seismic response, Perturbation theory, Natural frequencies

Through perturbation theory, results are obtained for the dynamic response of the very light equipment component(s) of tertiary equipment-structure systems. Both the three-degree-of-freedom and multi-degree-of-freedom models are examined. The case of all natural frequencies

of the subsystems distinct (detuning) as well as a natural frequency of each subsystem close or equal to one another (tuning) are examined.

86-186
Analysis of Short- to Medium-Range Seismic Attenuation Tests Using a Multilayered Viscoelastic Seismic Propagation Model
B.L. Carnes, J.R. Lundien
Army Engineer Waterways Experiment Station, Vicksburg, MD
Rept. No. WES/TR/EL-84-9, 219 pp (Nov 1984) AD-A149 771/8/GAR

KEY WORDS: Seismic waves, Wave propagation, Viscoelastic media

This study was conducted to provide a database from which to draw conclusive results on the efficiencies of seismic wave propagation in natural terrain and the resolution and fidelity of multiple frequency signals, and to supplement data for validation of theoretical models of seismic wave propagation. An extensive test program was conducted using an electrohydraulic vibrator, an impulse loader, and a vehicle as sources of seismic waves over a 5-m to 1-km range and using explosive seismic sources over a 1- to 10-km range. The results are presented for discrete frequency vibration test, tone burst tests, random noise vibration tests, and background noise tests for vehicle, impulse, and explosive tests.

86-187
Innovations in Earthquakes and Natural Hazards Research: Synthetic Accelerograms
G.B. Moore, R.K. Yin
COSMOS Corp., Washington, DC
Rept. No. NSF/CEE-84048, 53 pp (Dec 1984) PB85-166809/GAR

KEY WORDS: Earthquake damage

This case study is part of a project investigating the process by which innovations intended to reduce the effects of earthquakes and other natural hazards are utilized. The goal of the project is to improve the usefulness of these innovations to policymakers, state and local officials, service providers, and citizens. The study examines a research project that developed synthetic accelerograms, computer-derived simulations of earthquake ground motions. The accelerograms serve as a tool for analyzing the design of important and complex structures to ascertain their likely response to earthquake shaking. The study analyzes how an innovation in earthquake and natural hazards research was used for practical and policy purposes, why utilization occurred, and what potential policy implications can be drawn.

VIBRATION EXCITATION

86-188
Study of Transonic Flutter of a Two-Dimensional Airfoil Using the U-g and p-k Methods (Une Etude sur les Vibrations Aeroelastiques en Regime Transsonique d'Un Profil Aerodynamique Bidimensional au Moyen des Methodes U-g et p-k)
B.H.K. Lee
National Aeronautical Establishment, Ottawa, Ontario, Canada
Rept. No. NAE-LR-615, NRC-23959, 70 pp (Nov 1984) AD-A151 463/7/GAR

KEY WORDS: Airfoils, Flutter, Computer programs

Transonic flutter of an airfoil undergoing plunging and pitching oscillations is studied using the U-g and p-k methods. The aerodynamic coefficients are calculated using an improved version of an ONERA unsteady transonic aerodynamics code which include the second time derivative term of the velocity potential in the governing equation. Comparisons with LTRAN2-NLR show good agreement.

86-189
The Dynamics of Symmetric Post-Buckling
L.N. Virgin
University College London, London, UK
Intl. J. Mech. Sci., 27 (4), pp 235-248 (1985) 14 figs, 14 refs

KEY WORDS: Axial excitation, Natural frequencies, Buckling, Bifurcation theory, Initial deformation effects

The relationship between natural frequency and compressive load for a conservative elastic mechanical system characterized by symmetric buckling is examined. Application of some

general theory shows that for a perfect system, exhibiting a stable-symmetric point of bifurcation, the initial post-buckling curve of compressive load against the square of the natural frequency is linear and has a slope of - 1/2 that of the pre-buckling curve. Simple link models and discretized continuous systems are analyzed to illustrate the results of the general theory.

86-190
Experimental Determination of the Effect of Nonlinear Stiffness on the Vibration of Elastic Structures
G. Maymon, L.W. Rehfield
Georgia Inst. of Tech., Atlanta, GA
Israel J. Tech., 22 (1), pp 31-37 (1984/5) 6 figs, 1 table, 10 refs

KEY WORDS: Nonlinear stiffness, Vibration response, Elastic systems

A method for the determination of the coefficient of nonlinearity of a geometrical nonlinear elastic system is proposed. The method is based on measuring the jump-down points which exist in geometrically nonlinear systems. A plot of the amplitude squared vs. the frequency squared at the amplitude jump-down points for several excitation levels yields a straight line whose slope is related to the coefficient of nonlinearity. The method is demonstrated on a simple elastic system -- a clamped-clamped beam -- and excellent results are obtained.

86-191
Dynamic Stiffness Method for Exponentially Varying Harmonic Excitation of Continuous Systems
A.Y.T. Leung
Univ. of Hong Kong, Hong Kong
J. Sound Vib., 98 (3), pp 337-347 (Feb 8, 1985) 1 fig, 1 table, 10 refs

KEY WORDS: Harmonic excitation, Continuous systems, Dynamic stiffness method

The dynamic stiffness method relating the amplitudes of applied forces and responses of a harmonically vibrating continuum enables the infinite number of natural modes to be represented by a finite number of nodal co-ordinates for continuous structures of beams and folded plates. The methd has been applied almost exclusively to harmonic, or periodic, oscillations due mainly to the rather misleading intuition that only harmonic vibrations can be described by solutions with separate time- and space-dependent factors. It is shown here that a much wider class of problem of exponentially varying harmonic excitations can also be analyzed by the dynamic stiffness method. The extension is achieved simply by using complex frequency parameters. The forced response (that is, the part of the response which is independent of the initial conditions) can be obtained directly by solution of linear equations.

86-192
Periodic Solutions and the Stability in a Non-Linear Parametric Excitation System
T. Kotera, S. Yano
Kobe Univ., Kobe, Japan
Bull. JSME, 28 (241), pp 1473-1480 (July 1985) 6 figs, 7 refs

KEY WORDS: Fluid-induced excitation, Parametric vibrations, Self-excited vibrations, Van der Pol method

Phenomena on the interaction between self-excited and parametric vibrations in the flow-induced vibration problems are described by a differential equation of Van der Pol-Mathieu type with the nonlinear restoring force as a mathematical model. Periodic solutions in the regions of parametric resonances of the first and the second orders are approximated by the sum of two frequency components. These approximated solutions have high accuracy. The stability criterion of periodic solutions is established by approximately obtaining the regions of instability in Hill's equation for small disturbance from periodic solutions.

86-193
Maxima for a Vectorial Parameter from a Random-Multidirectional Source
K.G. Nolte, F.H. Hsu
J. Energy Resources Tech., Trans. ASME, 107 (2), pp 238-243 (June 1985) 2 figs, 5 refs

KEY WORDS: Fluid-induced excitation

Forces on structures result from vector quantities such as wind velocity and ocean waves which generally have a random and multidirectional source. Normally, design practices ignore the

directional aspect of the source and assume that the source's energy content is unidirectional. This paper presents a theoretical analysis for the maxima from a random-multidirectional source. The analysis is in terms of bounds on the maxima for a narrow-band frequency source. To reduce the abstract nature of the analysis, the discussion and examples are given in terms of the wave-particle velocity in a random sea, although the results are generally applicable to any vectoral quantity that is consistent with the outlined assumptions.

THERMAL EXCITATION

86-194
Free Vibrations of a Pyroelectric Layer of Hexagonal (6 mm) Class
H.S. Paul, K. Renganathan
Indian Inst. of Tech., Madras, 600 036, India
J. Acoust. Soc. Amer., 78 (2), pp 395-397 (Aug 1985) 2 figs, 6 refs

KEY WORDS: Temperature effects, Piezoceramics, Vibration response

The exact frequency equation for the free vibrations of a pyroelectric (thermo-piezoelectric) layer of (6 mm) class is obtained. The surfaces of the layer are kept traction free, completely coated with electrodes which are shorted and thermally insulated. The symmetric and the antisymmetric modes of vibration are discussed numerically. The dispersion curves have been presented graphically for a barium titanate layer.

MECHANICAL PROPERTIES

DAMPING

86-195
Impact Damper with Granular Materials (2nd Report, Both Sides Impact in a Vertical Oscillating System)
Y. Araki, I. Yokomichi, J. Inoue
Kyushu Inst. of Tech., Kitakyushu, Japan
Bull. JSME, 28 (241), pp 1466-1472 (July 1985) 11 figs, 5 refs

KEY WORDS: Impact dampers, Granular materials

A new type of impact damper consisting of a bed of granular materials moving in a container fixed to the primary vibrating system is investigated. The problem is to determine the characteristics of the damper with granular materials, for reducing the vibration of a single degree-of-freedom system when the driving force is simple harmonic. Experimental models were tested in the laboratory and analyses were made to find steady state periodic solutions of the system.

86-196
Stability of Squeeze Film Damped Multi-Mass Flexible Rotor Bearing Systems
L.J. McLean, E.J. Hahn
Royal Military College, Duntroon, Australia
J. Trib., Trans. ASME, 107 (3), pp 402-410 (July 1985) 6 figs, 10 refs

KEY WORDS: Squeeze-film dampers, Flexible rotors

A technique is presented for investigating the stability of and the degree of damping in the circular synchronous orbit equilibrium solutions pertaining to radially symmetric multi-mass flexible rotor bearing systems. It involves the analysis of appropriate linearized perturbation equations about the equilibrium solutions and is applicable to systems with several squeeze film dampers. For a system with a single damper, stability threshold maps, independent of unbalance distribution, may be found in terms of the same damper parameters and operating conditions as the equilibrium solutions, thereby allowing for damper design and performance monitoring. The technique is illustrated for a simple symmetric four degree of freedom flexible rotor with an unpressurized damper.

86-197
Non-Proportional Damping in Modal Analysis
V.W. Snyder
Michigan Technological Univ., Houghton, MI
Experimental Mechanics, Proc. of 1985 SEM Spring Conf., June 9-14, 1985, Las Vegas, NV, pp 107-111, 9 figs, 1 table, 8 refs

KEY WORDS: Modal analysis, Damping effects, Nonproportional damping

This paper is a tutorial on non-proportional damping in modal analysis and its effect on the total response. The classical modal analysis is reviewed and the Hamiltonian 2N-space (state variables) is used to show the difference between the two types of problems. The current numerical indices for non-proportional damped systems are examined.

86-198
An Improved Driving Point Measurement Method for Determining Material Damping
J.D. Rogers, K.G. McConnell, L.W. Zachary
Iowa State Univ., Ames, IA
Experimental Mechanics, Proc. of 1985 SEM Spring Conf., June 9-14, 1985, Las Vegas, NV, pp 807-812, 4 figs, 1 table, 7 refs

KEY WORDS: Resonance tests, Material damping, Single point excitation technique

A modified system resonance testing technique using single point input measurements for determining material damping is presented. Preliminary results indicate the new method shows good promise for continued development.

86-199
Damping and Vibration Characteristics of an Aluminum Filled Epoxy
J.D. Rogers, L.W. Zachary, K.G. McConnell
Iowa State Univ., Ames, IA
Experimental Mechanics, Proc. of 1985 SEM Spring Conf., June 9-14, 1985, Las Vegas, NV, pp 792-806, 11 figs, 5 tables, 16 refs

KEY WORDS: Aluminum, Steel, Damping coefficients

The usefulness of a particular aluminum particle filled epoxy for dynamic modeling is examined. Damping characteristics are presented for the aluminum particle filled epoxy and for some structural metals. Predicted and experimentally determined natural frequencies for geometrically similar portal frames constructed from the aluminum particle filled epoxy and two metals are presented.

FATIGUE

86-200
Transient Inelastic Behavior in Low-Cycle Fatigue
Y. Leroy, D. Lefebvre
Brown Univ., Providence, RI
Experimental Mechanics, Proc. of 1985 SEM Spring Conf., June 9-14, 1985, Las Vegas, NV, pp 695-701, 6 figs, 10 refs

KEY WORDS: Fatigue life, Steel

The cyclic strain-hardening and softening of A516 steel are experimentally described from uniaxial cyclic controlled strain tests carried out on solid cylindrical specimens. A cyclic plasticity model, based on a linear combination of the isotropic and kinematic models, by means of a variable factor, capable of describing the evolution of the hysteresis loop shape and estimating the stable stress amplitude, is developed. A good correlation is obtained with six strain level tests on the studied material.

86-201
The Constant Life Fatigue Diagram of 42CrMoA Alloy Steel and Its Application to the Reliability Analysis of Diesel Engine Connecting Rod
Yu-ren Cheng, Nai-shi Huang, Yan-jun Sun
Northern Jiaotong Univ., Beijing, China
Experimental Mechanics, Proc. of 1985 SEM Spring Conf., June 9-14, 1985, Las Vegas, NV, pp 435-438, 4 figs, 6 refs

KEY WORDS: Fatigue life, Steel, Diesel engines

The fatigue limit and its probability distribution of 42CrMoA alloy steel is investigated and the constant life diagram with 95% survival rate is plotted. Using an s-S model, the reliability of the connecting rod of a powerful diesel engine is estimated.

86-202
Low Cycle Fatigue Behaviour of Dual-Phase Steel with Different Volume Fractions of Martensite
S.R. Mediratta, V. Ramaswamy, P. Rama Rao
R&D Ctr. for Iron and Steel, Steel Authority of India Ltd., Ranchi 834002 India
Intl. J. Fatigue, 7 (2), pp 101-106 (Apr 1985) 10 figs, 2 tables, 18 refs

KEY WORDS: Fatigue life, Steel, Experimental data

Completely reversed low cycle fatigue tests were carried out on 3 mm thick sheet specimens of a dual-phase steel treated to give 1.5 to 28% martensite without changing the carbon content. Hysteresis loop shape, stress/strain response and plastic strain energy as a function of applied cycles are analyzed for different microstructures.

86-203

The Fatigue Crack Growth of a Ship Steel in Seawater under Spectrum Loading

Y.W. Cheng
U.S. Dept. of Commerce, National Bureau of Standards, Boulder, CO

Intl. J. Fatigue, Z (2), pp 95-100 (Apr 1985) 8 figs, 1 table, 20 refs

KEY WORDS: Fatigue life, Crack propagation, Steel, Ships, Off-shore structures

Fatigue crack growth of ABS EH36 steel under spectrum loading intended to simulate sea loading of offshore structures in the North Sea was studied using fracture mechanics. A digital simulation technique was used to generate samples of load/time histories from a power spectrum characteristic of the North Sea environment.

86-204

Fatigue Crack Growth from Sharp Notches

C.S. Shin, R.A. Smith
Cambridge Univ., Cambridge, UK

Intl. J. Fatigue, Z (2), pp 87-93 (Apr 1985) 10 figs, 13 refs

KEY WORDS: Fatigue life, Crack propagation, Steel

Notch-like stress raisers occur widely in engineering components. They are preferred sites for crack initiation when the components are subjected to cyclic loadings. Thus the growth of cracks initiated from notches is very relevant to design against fatigue failures. Schematic models proposed to explain the departure of notch crack growth from linear elastic fracture mechanics predictions are briefly reviewed. Different methods of measuring crack closure are compared.

86-205

Fatigue Strength of High Strength Dual-Phase Steel Sheet

J.O. Sperle
Central R&D, SSAB Svenskt Stal AB, Borlange, Sweden

Intl. J. Fatigue, Z (2), pp 79-86 (Apr 1985) 6 figs, 4 tables, 17 refs

KEY WORDS: Fatigue tests, Hole-containing media, Steel

Fatigue tests were carried out on lean-alloyed dual-phase steel with tensile strength ranging from 300 - 800 MPa. Smooth specimens and specimens with punched holes were tested. The fatigue strength of dual-phase steel was found to be similar to that of other types of steel (e.g., solution hardened or microalloyed steels) of equal tensile strength. The fatigue strength increases with increasing yield strength.

86-206

Crack Growth in Aluminium Alloy Sheet Material under Flight-Simulation Loading

J. Schijve, A.M. Vlutters, Ichsan, J.C. Provo Kluit
Delft Univ. of Tech., Delft, The Netherlands

Intl. J. Fatigue, Z (3), pp 127-136 (July 1985) 11 figs, 4 tables, 25 refs

KEY WORDS: Crack propagation, Fatigue life, Aluminum, Flight simulation

Crack propagation tests were carried out on 2024-T3 sheet specimens to study the effects of omitting low-amplitude cycles from the gust-dominated TWIST load sequence (MiniTWIST) and the removal of small ranges from the manoeuvre-dominated FALSTAFF load sequence (short FALSTAFF). In other tests high-amplitude loads of TWIST and MiniTWIST were truncated at different levels. The results are compared with data from similar test programs, including crack initiation. Attention is paid to unstationary crack growth retardation and a transient retardation during initial crack growth started by an artificial crack.

86-207

Study of Acoustic Emission (AE) Associated with Fatigue Damage to Aluminum Alloys

M. Cherfaoui, J.F. Chretien, J.P. Spieldener, J. Roget

Univ. de Technologie de Compiegne, Compiegne, France
Acoustic Emission Monitoring and Analysis in Manufacturing, Winter Annual Mtg. of ASME, New Orleans, LA, Dec 9-14, 1984, pp 35-53, 16 figs, 5 tables

KEY WORDS: Fatigue life, Aluminum, Acoustic emission

The acoustic emission detected during the initiation and fatigue crack propagation in two different aluminium alloys is analyzed. The forms of loading spectra applied are commonly used in the aeronautical industry for simulation of aircraft flights.

86-208
Creep-Fatigue Interactions in 7075 Aluminum at Room Temperature
A.D. Freed, N.F. Enke
Univ. of New Hampshire
Experimental Mechanics, Proc. of 1985 SEM Spring Conf., June 9-14, 1985, Las Vegas, NV, pp 649-651, 2 figs, 2 refs

KEY WORDS: Fatigue life, Aluminum

Specimens of 7075-T651 aluminum were loaded in axial push-pull to generate various amounts of fatigue damage and then held at a constant tensile load to allow creep. The creep strain in a given time decreased with increasing accumulation of fatigue damage. This behavior is represented by a power-law relationship.

86-209
Keeping Elastomers Sprightly — By Design
P.G. Howgate
Rubber and Plastics Res. Assn. of Great Britain, Shawbury, UK
Chartered Mech. Engr., 32 (5), pp 39-41 (May 1985), 4 figs, 2 refs

KEY WORDS: Elastomers, Fatigue life

Rubber-like materials, under the broad generic name elastomers, have been used in engineering applications for well over a century. Most engineers know of their physical properties - low distortional modulus, high dilatational modulus, very high strain capability - but often they are confused when it comes to using elastomers to fulfill a particular engineering rquirement. The problem is lack of understanding of a material which is unique. This article aims to introduce readers to design in elastomers to reduce the effect of fatigue.

86-210
Damage Development During Fatigue of Carbon-Black Loaded SBR
D. Lesuer, A. Goldberg, D. Hiromoto, J. Patt
Lawrence Livermore National Lab., Livermore, CA
Experimental Mechanics, Proc. of 1985 SEM Spring Conf., June 9-14, 1985, Las Vegas, NV, pp 702-706, 4 figs, 1 table, 4 refs

KEY WORDS: Fatigue life, Elastomers

Damage development in elastomers subject to fatigue has been evaluated for SBR formulations containing various amounts of carbon black. The damage has been quantitatively characterized by measuring the ultimate tensile strength of samples previously subjected to fatigue in tension. At ambient temperature, the material shows little degradation until critical fatigue stress levels (damage thresholds) are applied to the material.

86-211
An Automated Optical System for Rubber Fatigue Crack Propagation Measurement
T.S. Fleischman, D.O. Stalnaker
The Firestone Tire & Rubber Co., Akron, OH
Experimental Mechanics, Proc. of 1985 SEM Spring Conf., June 9-14, 1985, Las Vegas, NV, pp 688-694, 8 figs, 14 refs

KEY WORDS: Fatigue life, Elastomers

The problem of automating fatigue crack propagation resistance measurements on rubber and other highly extensible materials has been solved by incorporating a line scan camera into a data acquisition system. A discussion of the apparatus follows a review of the theoretical background and prior art related to rubber fatigue characterization.

86-212
Fatigue of Land-Based Structures
G.P. Tilly

Dept. of Transport, Crowthorne, Berkshire RG11 6AU, UK
Intl. J. Fatigue, 7 (2), pp 67-78 (Apr 1985), 15 figs, 44 refs

KEY WORDS: Fatigue life, Bridges, Structural members, Bolted joints

Some of the more important aspects of the fatigue of land-based structures are reviewed: the types of loading due to vehicles, wind and people are considered and examples are given of fatigue in service, taken from the literature on highway bridges. Several of the most common types of design detail that have to be assessed for fatigue are covered.

86-213
Dynamic Crack Curving and Branching Under Biaxial Loading
J.S. Hawong, A.S. Kobayashi, M.S. Dadkhah, B.S.J. Kang
Univ. of Washington, Seattle, WA
Experimental Mechanics, Proc. of 1985 SEM Spring Conf., June 9-14, 1985, Las Vegas, NV, pp 127-133, 9 figs, 2 tables, 18 refs

KEY WORDS: Crack propagation, Photoelastic analysis

A 16 spark-gap camera was used to record the dynamic photoelastic patterns of ten centrally cracked, Homalite-100 specimens which fractured under ten biaxial stress ratios ranging from 3.7 to 0. The dynamic photoelastic patterns of curved cracks were used to verify the previously developed dynamic crack curving criterion. Cracks, which immediately curved upon propagation in three specimens under high biaxial loadings, were used to verify the static counterpart of the dynamic crack curving criterion.

86-214
Optimization of the Torque Amplification Factors of the Rolling Mill Drive System
K. Prikyrl
Technical Univ., Brno, CSSR
Strojnicky Casopis, 36 (1), pp 45-52 (1985), 6 figs, 3 tables, 4 refs (In Czech)

KEY WORDS: Fatigue life, Shafts

Optimization of the torque amplification factors of a rolling mill drive system are presented.

86-215
The Development of a System for the Study of Fatigue Crack Growth up to 2000 Hz
A. Petrovich, W. Bessler
Mechanical Technology Inc., Latham, NY
Experimental Mechanics, Proc. of 1985 SEM Spring Conf., June 9-14, 1985, Las Vegas, NV, pp 682-687, 9 figs, 1 table

KEY WORDS: Fatigue life, Crack propagation

A system constructed for the study of fatigue crack growth under combined high/low cycle loading is described. Based on a voice coil electro-hydraulic servo-valve, the system was used to study fatigue crack growth in aircraft turbine disk alloy 718 under combined high and low cycle loading with a high cycle frequency up to 2000 Hz. A specimen was designed to minimize the frequency ranges over which dynamic stresses due to resonance are significant. The procedures for verifying the elimination of these dynamic stresses is described.

86-216
Interrupted Fatigue Tests of Laminated Composites
C.R., Jr. Kulp, H.W. Smith
Boeing Vertol
Experimental Mechanics, Proc. of 1985 SEM Spring Conf., June 9-14, 1985, Las Vegas, NV, pp 895-906, 6 figs, 17 refs

KEY WORDS: Layered materials, Fatigue tests

E-glass/epoxy and S-glass/epoxy fabric laminates were examined for changes in modulus caused by advancing fatigue.

86-217
Response of Layered Composites in the Presence of Progressive Cracking
S.R. Soni, R.Y. Kim
AdTech Systems Research Inc., Fairborn, OH
Experimental Mechanics, Proc. of 1985 SEM Spring Conf., June 9-14, 1985, Las Vegas, NV, pp 712-717, 10 figs, 3 tables, 5 refs

KEY WORDS: Layered materials, Fracture properties, Cracked media

A theoretical and experimental investigation of composite laminates in which the intensity of cracks increases with increasing load is pre-

sented. The effective engineering constants of such laminates are measured for different configurations. These constants are used in the stress analysis of the laminate to understand their response. Global-local variational model is used to conduct the stress analysis. Tensor polynomial failure criterion is applied to predict the successive ply failures of the laminate. During experimentation the intensity of cracks is measured at each step of the load increment. A comparison of response characteristics between cracked and crack-free laminates is done.

EXPERIMENTATION

MEASUREMENT AND ANALYSIS

86-218
Industrial Laser-Sensor for the Measurement of Back and Forth Motions (Industrieller Laser-Sensor fur Hin- und Herbewegungen)
R.A. Myllyla, R. Ahola
Universitat Oulu, Sektion Elektrotechnik, Finland
Feingeratetechnik, 34 (3), pp 105-106 (1985), 5 figs, 3 refs (In German)

KEY WORDS: Measuring instrumentation, Paper products, Vibration measurement

A noncontacting method for the analysis of back and forth motion of objects is described. Numerous results show that the method is best suited for the measurement of paper web flutter. Other applications such as the analysis of machinery vibrations, the measurement of some surface profiles and stereoscopic vision are also possible.

86-219
Non-contact Surface Vibration Analysis Using a Monomode Fibre Optic Interferometer Incorporating an Open Air Path
A.C. Lewis, A.D. Kersey
Univ. of Kent, Canterbury, Kent, UK
J. Phys., E: Sci. Instrum., 18 (7), pp 604-608 (July 1985), 5 figs, 12 refs

KEY WORDS: Noncontacting probes, Interferometers, Optical probes

A very high sensitivity non-contacting vibration analysis system based upon a monomode fibre optic Mach Zehnder interferometer incorporating an open air path is described. The system was operated in both a closed loop limited tracking range homodyne mode and an effectively infinite tracking range novel pseudo-heterodyne mode.

86-220
Suppression of Vibration Effects on Piezoelectric Crystal Resonators
V.J. Rosati
Dept. of Army, Washington, DC
U.S. Patent 4-453 141, 5 pp (June 5, 1984)

KEY WORDS: Quartz crystals, Resonators, Vibration control

An active method and apparatus for suppressing or cancelling the effects of vibration on quartz crystal controlled oscillators by generating an electrical signal which is a replica of the vibration acting on the crystal resonator is described. The signal is properly phased and applied directly to the crystal electrodes which operates to substantially eliminate unwanted vibration-induced sidebands in the signal output of the oscillator.

86-221
Multiplexing Ground Motion Instrumentation Cables Downhole
D.B. Longinotti
EG&G Energy Measurements, Inc., San Ramon Operations
Experimental Mechanics, Proc. of 1985 SEM Spring Conf., June 9-14, 1985, Las Vegas, NV, pp 252-257, 6 figs, 3 tables

KEY WORDS: Underground explosions, Nuclear explosion effects, Measuring instrumentation

A system has been designed that consists of several instrumentation canisters, connected by multiple-shielded-pair cables to a multiplex canister, which combines the signals of up to four instrumentation channels onto a single coaxial cable for uphole transmission. The downhole multiplex canister system receives d-c signals or carrier system signals from below, frequency modulates each channel, mixes the four FM channels into a single composite signal, and superimposes the composite signal onto the d-c power in a single coaxial cable. This system

can survive in a severe dynamic and external stress environment with transient accelerations of up to 250 g's, velocities up to 25 m/s, and external pressures up to 300 bar (30 Mpa).

86-222
Force and Torque Measurement, A Technology Overview. Part 1 - Force
S.S. Gindy
Eaton Corp.-Lebow
Exptl. Tech., 9 (6), pp 28-33 (June 1985), 17 figs, 1 table

KEY WORDS: Force measurement, Measuring instrumentation

Although direct comparison with standard weights is still one of the most accurate means of load measurement, a variety of physical principles are now successfully used in other types of transducers. In addition to mechanical devices that multiply (magnify) loads, there are transducers that take advantage of phenomena such as elasticity, reflection of light, interference of light waves, electrical resistance, magnetism, inductance or sound. Among these, the ones that are based on elasticity are the ones that attract most of the designs. In this type of transducer, the linearity between the force and corresponding strain induced in an elastic member is made use of in measuring this force through monitoring the strain, or extension. Such force transducers are usually called strainometers or extensometers.

86-223
Time Series Analysis of Acoustic Emission Signals from Glass Reinforced Plastics
R.M. Belchamber, D. Betteridge, M.P. Collins, T. Lilley
BP Res. Ctr., Middlesex, UK
Acoustic Emission Monitoring and Analysis in Manufacturing, Winter Annual Mtg. of ASME, New Orleans, LA, Dec 9-14, 1984, pp 1-9, 7 figs, 4 refs

KEY WORDS: Time series analysis method, Acoustic emission, Glass reinforced plastics

Time series analysis of random point processes has been applied to the acoustic emission signals produced when glass reinforced composites are stressed. This analysis seeks to determine any association between individual events; i.e., whether they occur in a random manner or in some predetermined sequence due to an underlying mechanism.

86-224
Measurement of Linkage Frequencies and Their Three-Dimensional Representation by Oscilloscope at a Continuously Variable Angle of Observation
G. Wustmann
Feinwerktech. u. Messtech., 93 (3), pp 153-155 (1985), 6 figs, 11 refs (In German)

KEY WORDS: Measuring instruments, Recording instruments

For the measurement and immediate representation of frequency functions of two simultaneously recorded signals, a unit is introduced which, apart from the data logger in the form of a RAM block, includes a read-out logic with analog interface. The connection to a commercial oscilloscope provides quasi three-dimensional representations of the frequency peak at any measuring time, and in almost any perspective directly adjustable by the user by means of resistances.

86-225
Ultrasonic Displacement Measurements Using Digital Correlation
M.A. Hamed, T.C. Chu
Univ. of New Orleans, New Orleans, LA
Experimental Mechanics, Proc. of 1985 SEM Spring Conf., June 9-14, 1985, Las Vegas, NV, pp 819-822, 6 figs, 4 refs

KEY WORDS: Displacement measurement, Ultrasonic techniques, Digital techniques

A basic theory of digital correlation is described which utilizes the ubiquitous wave characteristics in ultrasonics. The ultrasonic pulse-echo maps are digitally recorded before and after deformation and are stored directly into a computer through a computer based pulse-echo system. Deformation gradients and displacement components are calculated by numerical correlation of small subsets of the deformed configuration. The method is illustrated by several examples which describes the effect of object motion on the calculation measurements.

86-226
Low-Noise Noise
J. Pumplin
Michigan State Univ., East Lansing, MI
J. Acoust. Soc. Amer., 28 (1), pp 100-104 (July 1985), 2 figs, 5 refs

KEY WORDS: Spectrum analysis, Noise analyzers

A practical method of computation is described for making periodic signals which have a given frequency spectrum and which minimize the variance in power as a function of time. These signals can be used to measure the spectral response of a system (the transfer function): they represent a significant improvement over traditional random-phase and minimum peak value approaches.

86-227
Sensitivity Analysis Based on Experimental Modal Parameters
C. Van Karsen
Structural/Kinematics Corp., Troy, MI
Experimental Mechanics, Proc. of 1985 SEM Spring Conf., June 9-14, 1985, Las Vegas, NV, pp 890-894, 3 tables, 6 refs

KEY WORDS: Structural modification techniques, Modal analysis

A new sensitivity analysis technique is described which can be used as a guide to modification efforts. This technique calculates the sensitivity of natural frequency, modal damping, and modal displacement to changes in local mass, stiffness, and damping. The sensitivity analysis is based upon the same modal parameters that are used to model the structure for eigenvalue modification techniques.

86-228
Enhanced Vibration Controllability by Minor Structural Modifications
R.T. Haftka, Z.N. Martinovic, W.L., Jr. Hallauer
Virginia Polytechnic Inst. and State Univ., Blacksburg, VA
AIAA J., 23 (8), pp 1260-1266 (Aug 1985), 8 figs, 5 tables, 10 refs

KEY WORDS: Structural modification techniques, Vibration control, Active vibration control, Spacecraft

A procedure for checking whether small changes in a structure have the potential for significant enhancements of its vibration control system is described. The first step in the procedure consists of the calculation of the sensitivity of the required strength of the control system to small changes in structural parameters. The second step consists of the optimization of the structural parameters to produce maximal reduction in required control system strength with minimal change in the structure. The procedure has been demonstrated for a flexible beam supported by four cables and controlled by a rate feedback, single-colocated, force-actuator velocity-sensor pair.

86-229
The Transient Analysis of a Structure Using a Modal Model
T.M. Gaught, B.J. Dobson
Royal Naval Engineering College, Manadon, Plymouth, Devon, UK
Experimental Mechanics, Proc. of 1985 SEM Spring Conf., June 9-14, 1985, Las Vegas, NV, pp 98-102, 6 figs, 5 refs

KEY WORDS: Experimental modal analysis, Modal models, Acceleration measurement, Mode shapes

Experimental modal analysis is used to characterize the dynamic behavior of a structure in terms of the natural frequencies, mode shapes and damping. Using the parameters extracted from this analysis a mathematical model is generated to predict the transient behavior of the structure subjected to an impact. A time-marching algorithm is employed to predict the acceleration response which is compared to experimental data. The effects of varying the number of modes included in the model and the duration of the time step are investigated.

86-230
Modal-Tuning Improves Impact Testing
R.W. Lally
PCB Piezotronics, Inc., Depew, New York
Experimental Mechanics, Proc. of 1985 SEM Spring Conf., June 9-14, 1985, Las Vegas, NV, pp 103-106, 4 figs, 3 refs

KEY WORDS: Impact hammer tests, Experimental modal analysis, Tuning, Mode shapes

The natural resonances of conventional impact hammer structures were determined to be the cause of spurious glitches in frequency response function measurements made during impact testing. By modal tuning, or tuning the mode shapes of the hammer structure, an impact hammer was developed which functions and feels better.

86-231
Data Dependent Systems Approach to Modal Analysis Via State Space
S.M. Pandit, N.P. Mehta
Michigan Technological Univ., Houghton, MI
J. Dynam. Syst., Meas. Control, Trans. ASME, 107 (2), pp 132-138 (June 1985), 3 tables, 19 refs

KEY WORDS: Modal analysis, Data dependent systems, State space approach

The application of the data dependent systems (DDS) methodology is proposed for modal identification and characterization. Difference equation models derived from sampled free and forced response information are shown to quantitatively define the dynamic properties of the system. A modal decomposition of the DDS models, based on modern linear system theory in the state space format and analyzed from the standpoint of theoretical modal analysis, yields the system eigenvalues and eigenvectors, and the parameters of a lumped structural model. The theoretical background is presented in detail; its validity is established by means of a simulation study. Advantages of the DDS approach are discussed.

DYNAMIC TESTS

86-232
Acoustic Emission Monitoring of Space Shuttle Tiles
W.L. Castner, L.K. Crockett, F.E. Sugg
Experimental Mechanics, Proc. of 1985 SEM Spring Conf., June 9-14, 1985, Las Vegas, NV, pp 470-472, 7 figs

KEY WORDS: Testing techniques, Acoustic emission, Space shuttles, Heat shields, Tiles

Late in the development of the space shuttle thermal protection system, a major problem was encountered with the attachment of the tiles to the spacecraft's exterior skin. To insure an adequate margin, each tile had to be proof tested. The risk of damaging a tile during proof test was quite high. For this reason, an acoustic emission system was developed and used in conjunction with the proof test to insure no significant damage occurred.

86-233
Acoustic Emission in Carbon-Carbon
G.F. Hawkins, M. Buechler, R.A. Meyer
The Aerospace Corporation, El Segundo, CA
Experimental Mechanics, Proc. of 1985 SEM Spring Conf., June 9-14, 1985, Las Vegas, NV, pp 827-832, 7 figs

KEY WORDS: Acoustic emission, Nondestructive tests, Composite materials, Carbon

Carbon-carbon is a strong, lightweight material which can withstand extremely high temperatures. Because of these properties it is used to make the exit cones of the rocket motors which lift satellites from the shuttle to higher orbits. There is no backup system for an exit cone so it must perform perfectly the first (and only) time in order for the mission to be a success. A reliable nondestructive test for this material must be developed to give the level of confidence required in these costly missions. To this end a study was conducted of the acoustic emissions from carbon-carbon composites.

86-234
NDE of Composites Using Laser Generated Acoustic Waves
W.H. Prosser, R.E., Jr. Green
Johns Hopkins Univ., Baltimore, MD
Experimental Mechanics, Proc. of 1985 SEM Spring Conf., June 9-14, 1985, Las Vegas, NV, pp 340-346, 7 figs, 13 refs

KEY WORDS: Composite materials, Nondestructive tests, Lasers, Sound waves

Although acoustical techniques offer many useful and versatile nondestructive methods for evaluating composite materials, the need to use an acoustical impedance matching couplant between transducer and composite causes probl ns. The present paper describes how use of laser generating and detecting acoustic systems eliminates

these problems and offers unique opportunities for innovative practical applications.

86-235
Vibration Testing Using Thermoelastic Stress Analysis
S.S. Russell
Univ. of South Carolina, Columbia, SC
Experimental Mechanics, Proc. of 1985 SEM Spring Conf., June 9-14, 1985, Las Vegas, NV, pp 532-534, 3 refs

KEY WORDS: Vibration tests, Thermoelasticity

The thermoelastic effect can be used to determine the hydroelastic stress field in a body undergoing cyclic mechanical excitation. A device that measures this effect is the SPATE 8000 of Ometron Inc. The temperature field is sensed remotely via an infrared detector, which is then cross-correlated with a reference signal. The reference signal can be the servohydraulic control signal, if the structure is being loaded with servohydraulics or from an accelerometer. The cross-correlation processing allows temperature measurements on the order of one thousandth of a degree Kelvin provided that the temperature measured is cycling at the same frequency as the reference signal. The objectives of this study are to determine is thermoelastic stress analysis can be used for mechanical vibration modal analysis of structures, and to derive the equations and procedures for performing a thermoelastic modal analysis on an example structure. The modal analysis of the example study should obtain the mode shape, the modal amplitude, and the boundary conditions of the vibrating structure.

86-236
Computational Aspects of a Seismic Performance Test Method Using On-Line Computer Control
Pui-Shum B. Shing, S.A. Mahin
Univ. of California, Berkeley, CA
Earthquake Engrg. Struc. Dynam., 13 (4), pp 507-526 (July/Aug 1985) 16 figs, 21 refs

KEY WORDS: Seismic tests, Computer-aided techniques

The basic computational procedure of a newly developed seismic performance test method is presented and examined. This method uses a direct step-by-step integration technique to compute the displacement response of a test specimen subjected to a numerically specified seismic excitation record, utilizing the nonlinear restoring forces actually developed by the specimen during the experiment. Due to the limitations of the experimental procedure and conditions, special analytical assumptions and numerical methods must be adopted. The adequacy of such analytical techniques is evaluated and possible computational errors are identified.

DIAGNOSTICS

86-237
The Longitudinal Vibration Characteristics of a Uniform Beam Containing Two Symmetric Discontinuities
B.S. Haisty, W.T. Springer
Univ. of Arkansas, Fayetteville, AR
Experimental Mechanics, Proc. of 1985 SEM Spring Conf., June 9-14, 1985, Las Vegas, NV, pp 389-393, 3 figs

KEY WORDS: Diagnostic techniques, Beams, Discontinuity-containing media

The objective of this research was to develop and test a mathematical model for a uniform beam containing two symmetric discontinuities which could be used to predict the magnitude and location of the discontinuities, as well as the reduction in the natural frequencies of vibration. Two models were developed for this study. The first was based on modeling the discontinuity as a linear spring using fracture mechanics concepts to arrive at the equivalent spring stiffness. The second was based on modeling the discontinuity as a uniform beam of reduced cross section. In both cases, receptance theory was used to develop the frequency equation. The discontinuities consisted of very thin notches cut to equal depths at the same location on opposite sides of the bar.

86-238
Damage Assessment of Transversely Vibrating Uniform Beams Containing a Symmetric Discontinuity
M.E. Reznicek, W.T. Springer
Texas Instruments, Inc., Lewisville, TX
Experimental Mechanics, Proc. of 1985 SEM Spring Conf., June 9-14, 1985, Las Vegas, NV, pp 404-409, 8 figs, 5 refs

KEY WORDS: Diagnostic techniques, Beams, Discontinuity-containing media, Natural frequencies, Failure analysis

A method for determining the location and magnitude of a symmetric discontinuity in a uniform beam has been determined via a developed relationship between the damage and the natural frequencies of transverse vibration. As a nondestructive testing technique the natural frequencies of a damaged bar are shown to be a reliable indicator for assessing damage. This was verified with a number of metallic bars containing a known damage.

86-239

The Diagnosis of Cylinder Power Faults in Diesel Engines by Flywheel Speed Measurement

J.W. Freestone, E.G. Jenkins
Loughborough Univ. of Tech., Leicestershire

Vehicle Condition Monitoring and Fault Diagnosis. IMechE Conf. Pubs. 1985-2, 1 Birdcage Walk, Westminster, London SW1, March 6-7, 1985, pp 15-24, 8 figs, 1 table, 2 refs (avail: SAE)

KEY WORDS: Diagnostic techniques, Diesel engines, Flywheels

A technique for estimating the power contribution of each cylinder in a multi-cylinder diesel engine is developed as an engine diagnostic capability. Robust magnetic sensors are used to obtain a waveform of engine speed fluctuations over one engine cycle under steady-state operating conditions. Adopting a simplified model of engine dynamics, a computer processes the time-history by application of the discrete Fourier transform to reproduce the crankshaft torque waveform. Subtracting the engine inertia torque provides an estimate of the gas-pressure torque waveform, from which the power contribution of individual cylinders can be determined.

86-240

Recent Developments in the Non-Intrusive Diagnosis of Engine Faults

K.N. Hitchcock
Froude Consine Limited, Gregory's Bank, Worcester

Vehicle Condition Monitoring and Fault Diagnosis. IMechE Conf. Pubs. 1985-2, 1 Birdcage Walk, Westminster, London SW1, March 6-7, 1985, pp 101-108, 6 figs (avail: SAE)

KEY WORDS: Diagnostic techniques, Frequency domain method, Ultrasonic techniques, Diesel engines

Development work carried out in the use of ultrasonic techniques for the accurate dynamic timing of engines is described and a number of piston ring and piston to cylinder wall effects are discussed. Work on frequency domain techniques for engine fault diagnosis is described along with a new test bed computer language which has radically reduced software cost and complexity.

86-241

Laser Tools for Diesel Engine Diagnosis

P.G. Eastwood, N.A. Halliwell, P. Gilbert
Univ. of Southampton, Southampton, UK

Vehicle Condition Monitoring and Fault Diagnosis. IMechE Conf. Pubs. 1985-2, 1 Birdcage Walk, Westminster, London SW1, March 6-7, 1985, pp 139-146, 6 figs, 11 refs (avail: SAE)

KEY WORDS: Diagnostic techniques, Diesel engines, Measuring instruments, Lasers, Velocity measurement

Two portable laser instruments are described which allow the engineer to simply stand and point laser beams at a target surface in order to obtain a measurement of time resolved vibration velocity. The first supplements the accelerometer and measures normal surface velocity but offers the advantage of noncontact measurement. The second instrument is a laser torsional vibrometer which measures torsional oscillations of rotating machinery parts and in particular crankshaft oscillation. Comparisons are made with the more standard technique which utilizes a slotted disc.

86-242

Diagnostic Analysis of Slide Matings by Means of Sound Emission (Diagnostik an Gleitpaarungen durch Schallemissionsanalyse)

A. Sturm, S. Uhlemann
Ingenieurhochschule Zittau, Sektion Kraftwerksanlagen und Energieumwandlung, Lehrgebiet Instandhaltung, German Dem. Rep.

Maschinenbautechnik, 34 (3), pp 129-132 (1985) 7 figs, 9 refs (In German)

KEY WORDS: Diagnostic techniques, Acoustic emission, Sliding friction

Acoustic emission analysis can be used not only for nondestructive testing of materials, but also for machinery diagnostics during operation. The article describes an application of the acoustic emission method for the diagnosis of friction change in slide matings. Tests were performed on operating machinery as well as in the laboratory.

86-243
Application of Acoustic Emission Technique to Detection of Rolling Bearing Failure
T. Yoshioka, T. Fujiwara
Ministry of International Trade and Industry, Ibaraki, Japan
Acoustic Emision Monitoring and Analysis in Manufacturing, ASME Winter Annual Mtg., New Orleans, LA, Dec 9-14, 1984, pp 55-75, 17 figs, 5 tables, 13 refs

KEY WORDS: Diagnostic techniques, Rolling contact bearings, Acoustic emission

The working principle of an acoustic emission (AE) source locating system developed for rolling contact bearings is described and experimental results of its use are presented. The system was made to determine the cause of acoustic signals emitted from a bearing and was comprised of a single-channel AE instrument, a magnetic detector and a locator. Also described are the characteristics of a noise eliminator which was fabricated to exclude background noises similar to the AE burst signals emitted from the bearings.

86-244
The Vibration Produced by Multiple Point Defects in a Rolling Element Bearing
P.D. McFadden, J.D. Smith
Cambridge Univ., Cambridge, England
J. Sound Vib., 98 (2), pp 263-273 (Jan 22, 1985) 8 figs, 2 tables, 4 refs

KEY WORDS: Diagnostic techniques, Rolling contact bearings, Multipoint excitation technique

A model for the high-frequency vibration produced by a single point defect on the inner race of a rolling element bearing under radial load is extended to describe the vibration produced by multiple point defects. The model incorporates the effects of bearing geometry, speed, load distribution, transfer function and the decay of vibration. A comparison of predicted and measured spectra for a bearing with two point defects confirms satisfactory performance of the model.

86-245
The Detection of Weld Cracks Using Ultrasonic Testing
T. Arakawa, S. Hirose, T. Senda
Ishikawajima-Harima Heavy Industries Co. Ltd., Shinakahara-cho-1, Isogo-ku, Yokohama, Japan
NDT Intl., 18 (1), pp 9-16 (Feb 1985) 11 figs, 2 tables, 6 refs

KEY WORDS: Crack detection, Welded joints, Ultrasonic techniques, Testing techniques

The detection of cracks in weldments using ultrasonic testing has been studied with particular reference to the directivity of the reflected waves from the crack surface and to the relation between crack size and height of the echo from the beam incident perpendicularly on the crack surface. Results obtained from scans with probes providing different beam angles indicate that adopting as a standard defect a transverse hole of 3.2 mm diameter, and with a sensitivity level set at -14 dB, searching from one examination surface with probes with straight, 45° and 60° beams would ensure detection of a crack of size corresponding to the standard defect irrespective of the orientation of the crack.

86-246
Three-Dimensional Crack Location by Acoustic Emission
C.B. Scruby, G.R. Baldwin
UKAEA Atomic Energy Res. Establishment, Harwell, UK
Rept. No. AERE-R-11277, 25 pp (June 1984) N85-15193/4/GAR

KEY WORDS: Diagnostic techniques, Acoustic emission, Failure detection, Fatigue life, Crack propagation

A four transducer transient recording system was used to detect acoustic emission events associated with the growth of a fatigue crack in a compact tension specimen of 7010 aluminum alloy. The location accuracy for the (x,y,z) coordinates of each event is + or - 0.5 mm. The principal emission source is believed to be inclusion fracture at, or close to, the tip of the crack, so that

the locus of emission events provides an image of the position and shape of the crack front. Using this system, the crack was observed to grow during cyclic fatigue from 3.2 mm to 5.6 mm over the whole crack front.

86-247
Internal Damping as a Diagnostic Indicator of Hyperbaric Chamber Integrity
R.L. Jones, G.E. Warren
Naval Civil Engrg. Lab., Port Hueneme, CA
Experimental Mechanics, Proc. of 1985 SEM Spring Conf., June 9-14, 1985, Las Vegas, NV, pp 394-403, 9 figs, 29 refs

KEY WORDS: Diagnostic techniques, Crack detection, Crack propagation, Internal damping

This investigation is concerned with monitoring the structural integrity of hyperbaric chambers using a structural integrity nondestructive evaluation technique (SINET). Specifically, the structural parameter of internal damping is investigated for the qualities desirable in a SINET monitor parameter. Successfully monitoring damage to a structure undergoing cyclic fatigue implies an evaluation technique with the capacity to quantify crack propagation. Quantification is accomplished by a set of constitutive equations relating to crack propagation to the SINET monitor parameter.

MONITORING

86-248
The Use of Speed Sensing for Monitoring the Condition of Military Vehicle Engines
T.H.B. Jewitt, B. Lawton
Ministry of Defence, Royal Ordnance Factory, Leeds, West Yorkshire
Vehicle Condition Monitoring and Fault Diagnosis. IMechE Conf. Pubs. 1985-2, 1 Birdcage Walk, Westminster, London SW1, March 6-7, 1985, pp 67-74, 10 figs, 1 table (avail: SAE)

KEY WORDS: Monitoring techniques, Diesel engines

Measurement of engine torque gives an excellent indication of engine condition. The application of instantaneous speed sensing as a means of deriving instantaneous acceleration and torque is described. Four different methods of analysis are investigated, their relative merits determined and recommendations are made to convert these research techniques into viable, in-service, diagnostic tools.

86-249
Remote Monitoring of Pipe Vibration
R.C. Sampson
Bechtel Power Corp., San Francisco, CA
Experimental Mechanics, Proc. of 1985 SEM Spring Conf., June 9-14, 1985, Las Vegas, NV, pp 329-336, 9 figs, 7 refs

KEY WORDS: Monitoring techniques, Pipelines, Nuclear reactor components, Experimental data

The problems of selecting measurement sites and interpreting vibration test data for nuclear piping systems that are not accessible to visual or tactile contact during normal operation are addressed. Remotely monitored instrument systems are therefore required. A general relation between resonant vibration amplitude, frequency, and maximum pipe stress is developed and verified by finite element model solutions for both simple and complex piping systems. A strategy for selection of vibration monitoring sites is outlined to assure the detection of every expected vibration mode within the frequency band of interest. The development of vibration evaluation and acceptance criteria at four different levels of significance is described. Typical test data, vibration capacities, and acceptance criteria are shown.

86-250
***Is Your Periodic Machinery Monitoring Program* Telling You the Truth, the Whole Truth, and Nothing But . . .?**
R.L. Leon
Liberty Technology Ctr., Inc., Conshohocken, PA
S/V, Sound Vib., 19 (6), pp 24-26 (June 1985) 3 figs

KEY WORDS: Monitoring techniques, Spectrum analysis

A periodic monitoring program that utilizes spectra instead of just overall vibration levels can yield significantly improved results. However, not all types of spectra are equivalent and not all programs using spectra can provide these improved results. The author discusses different

types of spectra and how some not only fail to provide improvement, but actually can provide incorrect results. Suggestions are given on how to acquire the spectral data so that maximum potential benefit can be achieved.

86-251
A Systematic Approach to Automating Machinery Management
R.M. Stewart
Stewart Hughes Ltd., Southampton, UK
S/V, Sound Vib., 19 (6), pp 14-23 (June 1985) 6 figs, 2 refs

KEY WORDS: Monitoring techniques, Computer-aided techniques

There exists a gulf between what process plant operating engineers want as machinery management information and what the so-called machinery condition or health monitoring industry currently provides. This gulf has two main components: the problem of interpreting health data; *e.g., vibration or performance* and the use of the interpreted data to manage the plant in the true sense of the word. This article looks at ways in which the gulf may be closed. A key part lies in the development of expert systems able to function in an engineering environment.

86-252
Diagnostic Analysis of Machinery with State-of--the-Art Equipment
W.J. McGuckin, E.J. Schramm
Vibration Specialty Corp., Philadelphia, PA
S/V, Sound Vib., 19 (6), pp 6-10 (June 1985) 5 figs

KEY WORDS: Monitoring techniques, Diagnostic instrumentation

A versatile diagnostic tool which can quickly and easily obtain vibration measurements is described. This new, lost cost diagnostic tool serves as a digital spectrum analyzer (multi-channel, with data taken simultaneously on three channels), a balance analyzer, and a predictive maintenance analyzer, all in one. The versatile ViB Processor is the heart of an easy to use, easy to expand, computerized predictive maintenance system that can monitor the condition of operating machinery; identify vibration problems and the need and timing for correction; establish trends; document machinery performance; and catalog and store data on floppy or hard discs.

86-253
Monitoring Tool Wear During Wood Machining with Acoustic Emission
R.L. LeMaster, L.B. Tee, D.A. Dornfeld
Univ. of California, Richmond, CA
Wear, 101 (4), pp 273-282 (Feb 15, 1985) 9 figs, 1 table, 12 refs

KEY WORDS: Monitoring techniques, Machine tools, Cutting, Acoustic emission

The purpose of this study was to determine the degree of change in acoustic emission (AE) during cutting as a cutter tool was worn. AE is defined as the stress or pressure waves generated during dynamic processes in materials and is generated during fracture, delamination, deformation and distortion of wood during cutting. The relationship between the AE output and the amount of wood cut close to linear in the initial stages of the blade wear. As the blade became severely worn, the AE levels dropped dramatically and an asymptotic relationship between the two variables became evident.

86-254
A Better Way to Monitor Bearings
D.B. Spencer, J.S. Hansen
Bingham-Willamette Co.
Hydrocarbon Processing, 64 (1), pp 75-76 (Jan 1985) 2 figs, 2 tables

KEY WORDS: Rolling contact bearings, Monitoring techniques

Unlike fluid film bearings, rolling element bearings traditionally have been difficult to monitor. Conventional case-mounted monitoring systems have several drawbacks for monitoring machines with rolling element bearings. Presented is a test comparison of five types of rolling element bearing monitoring systems on a 600 hp centrifugal pump. The newest method is based on a high gain, low noise eddy current proximity transducer. Electronic filters selectively separate the input signal into low and high frequency regions.

ANALYSIS AND DESIGN

ANALYTICAL METHODS

86-255
On Obtaining Mass Participation Factors Using "Equivalent" Structures
V.C. Matzen, C.E. Murphy
North Carolina State Univ., Raleigh, NC
Experimental Mechanics, Proc. of 1985 SEM Spring Conf., June 9-14, 1985, Las Vegas, NV, pp 91-97, 4 figs, 1 table, 10 refs

KEY WORDS: Mass participation factors, Seismic response, Buildings

Several methods for computing mass participation factors are described and compared. Included in this group are two new methods using equivalent reduced structures. Mass participation factors (MPFs) are quantities used to formulate the excitation terms in the equations of motion of a structure subjected to a time varying support motion. Both analytical and experimental methods are presented. The background in structural vibration theory necessary to understand the role of the MPFs is provided.

86-256
Stability and Convergence of Some Finite Element Algorithms for Nonlinear Elastodynamics
S.M. Hamdan, N. Patamapongs
Drexel Univ., Philadelphia, PA
Intl. J. Numer. Methods Engrg., 21 (6), pp 975-999 (June 1985) 3 figs, 27 refs

KEY WORDS: Finite element technique, Elastodynamic response

A series of direct-integration and model-expansion finite element algorithms for a geometrically and materially nonlinear elastodynamic problem are constructed and analyzed. The algorithms are constructed by temporally approximating the individual nonlinear stiffness terms such that discrete conservation laws are obtained. This conservative property has a positive effect in providing a stable approximation, and in addition allows the stability properties of the algorithms to be easily assessed. Stability and convergence criteria for the algorithms are rigorously established using an energy method.

86-257
An Equivalent Linearization Algorithm for Nonlinear System Limit Cycle Analysis
S.G. Abel, N.K. Cooperrider
Garrett Pneumatic Systems Div., Phoenix, AZ
J. Dynam. Syst., Meas. Control, Trans. ASME, 107 (2), pp 117-122 (June 1985) 12 figs, 17 refs

KEY WORDS: Limit cycle analysis, Eigenvalue problems

An approach for determining the characteristics of limit cycles in higher order systems with multiple nonlinearities is described. This method utilizes sinusoidal input describing functions to convert the nonlinear problem to an eigenvalue problem. A search procedure employing eigenvalue derivatives finds limit cycle conditions when they exist. This technique is relatively efficient and reliable and able to treat problems with strong nonlinearities such as Coulomb friction or relays. Two applications are presented: a mechanical servo positioner system and a railway bogie dynamics problem.

86-258
Sound Propagation Above an Inhomogeneous Plane: Boundary Integral Equation Methods
D. Habault
Centre National de la Recherche Scientifique, Marseille, France
J. Sound Vib., 100 (1), pp 55-67 (May 8, 1985) 4 figs, 15 refs

KEY WORDS: Sound propagation, Integral equations

A boundary integral equation method is used to compute the sound pressure emitted by a harmonic source above an inhomogeneous plane. The theoretical aspects of the problem are studied and a comparison between theoretical levels and experimental levels obtained in an anechoic rooms is presented. It shows that the boundary integral equation method is quite convenient for solving this kind of problem.

86-259
Sound Radiation by Baffled Plates and Related Boundary Integral Equations
P. Filippi
Centre National de la Recherche Scientifique, Marseille, France
J. Sound Vib., 100 (1), pp 69-81 (May 8, 1985) 1 fig, 14 refs

KEY WORDS: Sound propagation, Fluid-induced excitation, Baffles, Green function

The displacement of the plate is described by its Green's representation, involving the infinite fluid-loaded plate kernel. The boundary conditions lead to a system of two integral equations along the plate boundary. From a numerical point of view, the method is efficient because this kernel is represented in terms of Hankel functions and Laplace type integrals, which can be computed very fast. Numerical methods are described and an example is given.

86-260
An Improved Boundary Integral Equation Method for Helmholtz Problems
J.O. Adeyeye, M.J.M. Bernal, K.E. Pitman
Imperial College, London, UK
Intl. J. Numer. Methods Engrg., 21 (5), pp 779-787 (May 1985) 4 tables, 15 refs

KEY WORDS: Boundary value problems, Eigenvalue problems

The eigenvalue problem for the Laplace operator is numerical investigated using the boundary integral equation formulation. Three methods of discretization are given and illustrated with numerical examples.

86-261
The Duffing Oscillator: Analog Solutions and a Comparison with Harmonic Linearization
R.G. Frehlich, S. Novak
Univ. of California, San Diego, La Jolla, CA
Intl. J. Nonlin. Mech., 20 (3), pp 123-134 (1985) 6 figs, 13 refs

KEY WORDS: Duffing oscillators, Nonlinear theories

Analog solutions to Duffing's equation are presented. Parametric dependencies are discussed in detail. Quantitative comparisons are made with predictions of harmonic linearization.

86-262
Symmetric and Flat Bifurcations: An Oscillatory Phenomenon
A.S. Atadan, K. Huseyin
Univ. of Waterloo, Ontario, Canada
Acta Mech., 53 (3-4), pp 213-232 (Nov 1984), 5 figs, 10 refs

KEY WORDS: Bifurcation theory, Lumped parameter method, Harmonic balance method

Two distinct bifurcation phenomena associated with nonlinear autonomous lumped-parameter systems are analyzed fully in an n-dimensional state space. The analysis is asymptotic and is performed via an intrinsic harmonic balancing technique. The asymptotic equations of the limit cycles, bifurcating paths and the frequency-parameter relationships are derived in general terms explicitly. An illustrative example is provided.

86-263
On the Probability Density of the Envelope of a Sum of Random Vectors
G.H. Weiss, J.E. Kiefer
National Institutes of Health, Bethesda, MD
J. Sound Vib., 99 (3), pp 327-332 (Apr 8, 1985), 10 refs

KEY WORDS: Probability density function, Wave propagation

A most efficient way to calculate the probability density for the projection of the sum of n sinusoidal waves with differing amplitudes and phases that are uniform is to expand it in a Fourier series. The corresponding series for the envelope of such a series is known to be a Fourier-Bessel series. It is difficult to calculate moments of the envelope from this series. It is shown that by relating the probability density of the envelope to that of the projection one can find moments of the envelope in an easily computable form. It is also possible to calculate an approximate form for the density function for the envelope amplitude near its maximum value.

MODELING TECHNIQUES

86-264
The Dynamic Synthesis of General Non-Conservative Structures from Separately Identified Substructure Models
A.L. Hale, L.A. Bergman
Univ. of Illinois, Urbana-Champaign, IL

J. Sound Vib., 98 (3), pp 431-446 (Feb 8, 1985), 2 tables, 32 refs

KEY WORDS: Substructuring methods, Structural synthesis, Time domain method

The idea of synthesizing a number of directly identified substructure models is developed. Each substructure is tested separately and a substructure model is determined from time domain test data. Structural modeling concepts significantly affect the substructure identification and substructure coupling. The effects are examined in detail.

NONLINEAR ANALYSIS

86-265
Dynamics of a Nonlinear Oscillator with Feedback Control I: Local Analysis
P. Holmes
Cornell Univ., Ithaca, NY
J. Dynam. Syst., Meas. Control, Trans. ASME, 107 (2), pp 159-165 (June 1985), 3 figs, 15 refs

KEY WORDS: Nonlinear systems, Stability, Bifurcation theory

Stability and bifurcations of solutions of a single degree of freedom structural system with nonlinear stiffness, subject to linear feedback control is studied. The controller dynamics is modeled by a first order differential equation, so that the full system is of third order. Local bifurcations are considered: solutions branching from equilibria as various parameters (damping, gain, etc.) are varied. Using two different nonlinear stiffness functions, interactions between steady and periodic modes of instability are shown, leading to complicated dynamical behavior near the boundaries of the stable region of parameter space.

NUMERICAL METHODS

86-266
Method of Calculating Periodic Solutions of Second Order Dynamical Systems
A. Eydeland
Univ. of Wisconsin, Madison, WI
Rept. No. MRC-TSR-2768, 30 pp (Nov 1984), AD-A149 634/8/GAR

KEY WORDS: Numerical methods, Periodic response, Hamiltonian principle

Several numerical procedures for finding periodic solutions of Hamiltonian systems are considered. The original system of equations is replaced by a constrained variational problem. Numerical procedures are constructed by using the method of transformation of the objective functional applied to this variational problem. Global convergence results are established and different aspects of numerical implementation of the method are discussed.

86-267
Time Marching Numerical Solution of the Dynamic Response of Nonlinear Systems
D.J. Jones, B.H.K. Lee
National Res. Council of Canada, Ottawa, Ontario, Canada
Rept. No. NAF-AN-25, NRC-24131, 40 pp (Jan 1985), N85-21696/8/GAR

KEY WORDS: Numerical methods, Duffings differential equation, Structural members, Nonlinear systems

The nonlinear response of structural components, a single degree of freedom nonlinear response equation usually known as Duffing's equation is investigated. It is shown that a numerical solution is feasible and that some of the standard analytical approximations are not accurate in the peak region of the response curve.

86-268
Numerical Resolution Calculation for Elastic-Plastic Impact Problems
B.M. Creighton
Army Ballistic Res. Lab., Aberdeen Proving Ground, MD
Rept. No. BRL-MR-3418, SBI-AD-F300 591, 73 pp (Dec 1984), AD-A152 292/9/GAR

KEY WORDS: Wave propagation, Impact response, finite element technique, Elastic plastic properties

A brief summary of an investigation using the finite element method in the study of wave propagation and impact problems in solid materi-

als is presented. Guidelines are provided for the determination of the computational grid and the shape and size of the elements. Two examples are presented to show effects of mesh refinements on solution accuracy. Problems concerning the effects of artificial viscosity, as well as pressure and strain changes in the orientation of the grid, are presented. This study was performed with EPIC-2, a computer code for elastic-plastic impact calculations.

PARAMETER IDENTIFICATION

86-269
Global Indirect Identification Method
O. Danek
Czechoslovak Academy of Sciences, Prague, Czechoslovakia
Strojnicky Casopis, 36 (1), pp 35-44 (1985), 2 figs, 5 refs (In Czech)

KEY WORDS: System identification techniques, Global identification technique

An indirect identification method based on simultaneous evaluation of all dynamic measurements is proposed. For evaluation a mathematical model in n-dimensional space is chosen in the form of a resolvent. The method can be applied for nonconservative systems regardless of whether they fulfill the Maxwell-Betti conditions of symmetry.

COMPUTER PROGRAMS

86-270
Thermoelastic Stress Analysis Under Broad-Band Random Loading
W.M. Cummings, N. Harwood
National Engrg. Lab., East Kilbride, Scotland
Experimental Mechanics, Proc. of 1985 SEM Spring Conf., June 9-14, 1985, Las Vegas, NV, pp 844-850, 14 figs, 2 refs

KEY WORDS: Computer programs, Random excitation

The use of thermoelastic full field stress analysis techniques has increased rapidly in the last two or three years due mainly to the introduction of a production model of the SPATE equipment. A joint research project to study the applications aspects of this system was divided into three categories: calibration of SPATE for a range of materials and surface conditions, application of SPATE to structures with complex geometries and extension of the SPATE capability to include analysis of structures under broad-band random loading. This paper describes the investigation of structures under broad-band loading and the development of a hardware/software system to carry out relevant data acquisition and analysis.

86-271
Analysis of Dynamic Fracture Events
G.R. Irwin, W.L. Fourney, C.W. Schwartz, R. Chona
Univ. of Maryland, College Park, MD
Experimental Mechanics, Proc. of 1985 SEM Spring Conf., June 9-14, 1985, Las Vegas, NV, pp 872-884, 23 figs, 2 tables, 11 refs

KEY WORDS: Computer programs, Fracture properties, Finite element technique

The major features of SAMCR, a two-dimensional dynamic finite element code for the stress analysis of moving cracks, are described. The code has been shown to perform well in modeling the dynamic behavior of both uncracked and cracked structures and applications to the analysis of run-arrest events in polymeric laboratory samples, large thermally-shocked steel cylinders and wide-plate fracture specimens are presented. The usefulness and limitations of this and similar codes in the pre-test planning and post-test analysis of complex fracture experiments are also discussed.

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3-6 4th International Modal Analysis Conference [Union College] Los Angeles, CA (Ms. Rae D'Amelio, Union College, Wells House, Schenectady, NY 12308 - (518) 370-6288)

MARCH

5-7 Vibration Damping Workshop II [Flight Dynamics Laboratory of the Air Force Wright Aeronautical Labs.] Las Vegas, NV (Mrs. Melissa Arrajj, Administrative Chairman, Martin Marietta Denver Aerospace, P.O. Box 179, Mail Stop M0486, Denver, CO 80201 - (303) 977-8721)

24-27 Design Engineering Conference and Show [ASME] Chicago, IL (ASME)

APRIL

8-11 International Conference on Acoustics, Speech, and Signal Processing [Acoustical Society of Japan, IEEE ASSP Society, and Institute of Electronics and Communication Engineers of Japan] Tokyo, Japan (Hiroya Fujisaki, EE Department, Faculty of Engineering, University of Tokyo, Bunkyo-ku, Tokyo 113, Japan)

13-16 American Power Conference [ASME] Chicago, IL (ASME)

29-1 9th International Symposium on Ballistics [Royal Armament Research and Development Establishment] RMCS, Shrivenham, Wiltshire, UK (Mr. N. Griffiths, OBE, Head/XT Group, RARDE, Fort Halstead, Sevenoaks, Kent TN14 7BP, England)

MAY

5-9 32nd Annual Technical Meeting of the Institute of Environmental Sciences [IES] Dallas/Ft. Worth Airport, TX (IES, 940 E. Northwest Highway, Mt. Prospect, IL 60056 - (312) 255-1561)

12-16 Acoustical Society of America, Spring Meeting [ASA] Cleveland, OH (ASA Hqs.)

JUNE

3-6 Symposium and Exhibit on Noise Control [Hungarian Optical, Acoustical, and Cinematographic Society; National Environmental Protection Authority of Hungary] Szeged, Hungary (Mrs. Ildiko Baba, OPAKFI, Anker koz 1, 1061 Budapest, Hungary)

4-6 Machinery Vibration Monitoring and Analysis Meeting [Vibration Institute] Las Vegas, NV (Dr. Ronald L. Eshleman, Director, The Vibration Institute, 101 W. 55th St., Suite 206, Clarendon Hills, IL 60514 - (312) 654-2254)

8-12 Symposium on Dynamic Behavior of Composite Materials, Components and Structures [Society for Experimental Mechanics] New Orleans, LA (R.F. Gibson, Mech. Engrg. Dept., University of Idaho, Moscow, ID 83843 - (208) 885-7432)

JULY

20-24 International Computers in Engineering Conference and Exhibition [ASME] Chicago, IL (ASME)

21-23 INTER-NOISE 86 [Institute of Noise Control Engineering] Cambridge, MA (Professor Richard H. Lyon, Chairman, INTER-NOISE 86, INTER-NOISE 86 Secretariat, MIT Special Events Office, Room 7-111, Cambridge, MA 02139)

24-31 12th International Congress on Acoustics, Toronto, Canada (12th ICA Secretariat, P.O. Box 123, Station Q, Toronto, Ontario, Canada M4T 2L7)

SEPTEMBER

14-17 International Conference on Rotordynamics [IFToMM and Japan Society of Mechanical Engineers] Tokyo, Japan (Japan Society of Mechanical Engineers, Sanshin Hokusei Bldg., 4-9, Yoyogi 2-chome, Shibuyak-ku, Tokyo, Japan)

22-25 World Congress on Computational Mechanics [International Association of Computational Mechanics] Austin, Texas (WCCM/TICOM, The University of Texas at Austin, Austin, TX 78712)

29-30 VDI Vibrations Meeting [Society of German Engineers] Wurzburg, Fed. Rep. Germany (Society of German Engineers)

OCTOBER

5-8 Design Automation Conference [ASME] Columbus, OH (ASME)

5-8 Mechanisms Conference [ASME] Columbus, OH (ASME)

7-9 2nd International Symposium on Shipboard Acoustics ISSA '86 [Institute of Applied Physics TNO] The Hague, The Netherlands (J. Buiten, Institute of Applied Physics TNO, P.O. Box 155, 2600 AD Delft, The Netherlands, Telephone: xx31 15787053, Telex: 38091 tpddt nl)

14-16 57th Shock and Vibration Symposium [Shock and Vibration Information Center] New Orleans, LA (Dr. J. Gordan Showalter, Acting Director, SVIC, Naval Research Lab., Code 5804, Washington, D.C. 20375-5000 - (202) 767-2220)

19-23 Power Generation Conference [ASME] Portland, OR (ASME)

20-22 Lubrication Conference [ASME] Pittsburgh, PA (ASME)

NOVEMBER

3-6 14th Space Simulation Conference [IES, AIAA, ASTM, NASA] Baltimore, MD (Institute of Environmental Sciences, 940 E. Northwest Highway, Mt. Prospect, IL 60056 - (312) 255-1561)

30-5 American Society of Mechanical Engineers, Winter Annual Meeting [ASME] San Francisco, CA (ASME)

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ASLE American Society of Lubrication Engineers
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Manuscripts must be typed (double-spaced) and figures attached. It is strongly recommended that line figures be rendered in ink or heavy pencil and neatly labeled. Photographs must be unscreened glossy black and white prints. The format for references shown in **Digest** articles is to be followed.

Manuscripts must begin with a brief abstract, or summary. Only material referred to in the text should be included in the list of *References* at the end of the article. References should be cited in text by consecutive numbers in brackets, as in the following example:

> Unfortunately, such information is often unreliable, particularly statistical data pertinent to a reliability assessment, as has been previously noted [1].
>
> Critical and certain related excitations were first applied to the problem of assessing system reliability almost a decade ago [2]. Since then, the variations that have been developed and practical applications that have been explored [3-7] indicate . . .

The format and style for the list of References at the end of the article are as follows:

- -- each citation number as it appears in text (not in alphabetical order)
- -- last name of author/editor followed by initials or first name
- -- titles of articles within quotations, titles of books underlined
- -- abbreviated title of journal in which article was published (see Periodicals Scanned list in January, June, and December issues)
- -- volume, issue number, and pages for journals; publisher for books
- -- year of publication in parentheses

A sample reference list is given below.

1. Platzer, M.F., "Transonic Blade Flutter -- A Survey," Shock Vib. Dig., 7 (7), pp 97-106 (July 1975).

2. Bisplinghoff, R.L., Ashley, H., and Halfman, R.L., Aeroelasticity, Addison-Wesley (1955).

3. Jones, W.P., (Ed.), "Manual on Aeroelasticity," Part II, Aerodynamic Aspects, Advisory Group Aeronaut. Res. Dev. (1962).

Articles for the **Digest** will be reviewed for technical content and edited for style and format. Before an article is submitted, the topic area should be cleared with the editors of the **Digest.** Literature review topics are assigned on a first come basis. Topics should be narrow and well-defined. Articles should be 3000 to 4000 words in length. For additional information on topics and editorial policies, please contact:

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